Physics 12

Welcome

Course Outline/introduction

getting to know you

review grade 11?

What is Physics?

The study of physical phenomenon in our daily lives.

Study of energy or forces and changes in matter.

Physics is an experimental science.
Experiments in physics require measurement.
Measurement is comparing an observation to a standardized unit.

Metric System, SI base units:
Base
distance: metre, m
mass: kilogram, kg
time: second, s
Ampère, A electric current

Derived units:
gram, g
volume: litre, l
millilitre, ml = cm^3
1000 000 ml = 1 m^3
energy/ work = Joule, J = kg m^2/s^2
Force = Newtons, N = kg m/s^2
Power: Watt, W = J/s
Coulomb, C unit of charge

prefixes
deci, d 10^{-1}
centi, c 10^{-2}
milli, m 10^{-3}
micro, μ 10^{-6}
nano, n 10^{-9}
pico, p 10^{-12}
femto, f 10^{-15}

deca, da 10
Hecta, h 10^{2}
kilo, k 10^{3}
mega, M 10^{6}
Giga, G 10^{9}
Tera, T 10^{12}

Physics Intro

What is Physics?

Why stuff does what it does?

Science of matter and movement - forces or energy.

Wednesday, September 09, 2015
3:31 PM

Physics 12IB

Welcome

Outline

Getting to know you/IA

Measurement, Accuracy, Precision, Patterns

Measurement is comparing an observation to a standardized value.

Metric system

prefixes

d	deci	10^{-1}
c	centi	10^{-2}
m	mili	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
de	deca	10^{1}
h	hepta	10^{2}
k	kilo	10^{3}
M	mega	10^{6}
G	Giga	10^{9}
T	terra	10^{12}

Accuracy - How close to the actual or theoretical value a measurement is.

%error - % deviation from the accepted value

%error = |experimental value-theoretical/theoretical |
x 100%

eg. if you measure the acceleration due to gravity at 8.9 m/s^2, what is your percent error?

8.9-9.8=-0.9 -0.9/9.8=-0.0918
9.2% error

include a %error for all labs with a theoretical value (almost all the labs)

Precision - If you repeat a measurement, how close together are the values? Closer they are the better the precision.

The range of values is the uncertainty in the measurement. It depends on the instruments and how they are used. Best way to determine the uncertainty is to repeat the measurement but you can also guestimate it as half the smallest division on an analogue device or the last digit for a digital device.

eg. The time on the clock is 9:04.51 +/- half a second
a stopwatch can give the time to the hundredth of a second

5.02 s is the reading, so you can assume +/- 0.01 s for the device but the person using the stopwatch can have measurement uncertainties, like reaction time or anticipation that can mess up the precision.
Assume a person using a stopwatch has about +/- 0.1 s uncertainty.

The uncertainty is implied in the number of digits used in a measurement.
5.0s implies +/- 0.1s
5.00s implies +/- 0.01s

Sig fig rules:
all non zeros are significant
all zeros between significant digits are significant
all zeros after a decimal and after a sig fig are significant
zeros used for place counting are not significant

eg. give the number of sig figs for the following measurements:

3.2798 cm   5
6.0020 m   5
0.00002070 s   4
2.7080 x 10^{-15} m   5
5000 is 1 for chem teacher, for me ask.

add/subtracting

round the answer to least precise decimal place (NOT SIG FIGS)

multiplying/div round the answer to the least number of sig figs

eg.
2.020 cm + 0.13 cm =
2.020 cm x 0.13 cm =

4sf 2sf

$\boxed{\begin{array}{c} 2.15\text{ cm} \\ 0.26\text{ cm}^2 \end{array}}$

$$\begin{array}{r} 2.020 \\ +\ 0.13 \\ \hline 2.150 \end{array}$$

least precise

graphing:
title, axes with labels and units and consistent scale, plot points, draw a best-fit line show the trend (DO NOT CONNECT THE DOTS)

If linear - find the slope, intercept in put into an equation of the form y=mx+b but replace each term. eg F = 2.0 kg a + 0.20N

if non-linear - transform the data to make it linear, commonly you will square the x data or inverse the x data and regraph.

Measurement, Accuracy, Precision, Patterns

Accuracy - How close to the accepted value or theoretical value is the measurement.

%error - |experimental - theoretical|/theoretical x 100%

used in labs for an assessment of the data you collected.

eg. you do a lab an measure the acceleration of a falling object at 8.9 m/s^2, what is your % error?

experimental value: 8.9 m/s^2
theoretical value: 9.8 m/s^2

8.9-9.8=-0.9   0.9/9.8=0.0918 x100 = 9.2% error

don't say the data "proves" anything, say that the data

is within 9.2% of the theory.

precision: if you repeat a measurement, how close together are the values? if they are all really close together, they are precise.

eg. if you use a ruler and measure the width of a book at 15.0 cm while your partner re-measures and gets 13.0 cm, then there is a problem with your precision.

You might give the value as 14 cm +/- 1 cm

the +/- is the uncertainty in the measurement.

you estimate the uncertainty by:

1- look at the range of repeated measurements/2
2- half the smallest division on an analogue device
3- the smallest division of a digital device
4- other factors - like reaction time or anticipation that influence the measurement

eg. time on the clock is 10:34.38 +/- 0.5 seconds

a digital stopwatch gives values to the hundredth eg. 5.02 s but usually you give the value to the tenth only because of reaction time uncertainties.

5.0 s is a better estimate of the uncertainty.

5.0s implies +/- 0.1s

Rather than giving uncertainty for every measurement, we do significant digits, or figures (sig figs or SF) as a quick method.

Sig Fig rules:

all non-zeros are significant
zeros after a decimal and after a sig fig are significant
zeros in the middle are significant
zeros as placeholders are not significant

how many sig figs if the following:

0.00000023	2
250023	6
3.000	4
300.0	4
200	1 or ask (chem always 1)
3.7070×10^{38}	5

Adding/subtracting
- round your answers to the least precise decimal place (NOT SIG FIGS)

Multiply/divide - round your answer to the least number of sig figs.

4 SF   2 SF → 2 sfs

eg. 2.030cm x 0.13 cm= $\boxed{0.26\ cm^2}$

2.030cm + 0.13 cm

eg. 2.030cm x 0.13 cm= $\boxed{0.26\ cm^2}$
2.030cm + 0.13 cm =
5.34 km - 5127 m =

$$\begin{array}{r} 2.030 \\ 0.13 \\ \hline 2.160 \end{array} \rightarrow \boxed{2.16\ cm}$$

$$\begin{array}{r} 5.34 \\ -5.127 \\ \hline 0.213 \end{array}$$

$\boxed{0.21\ km}$

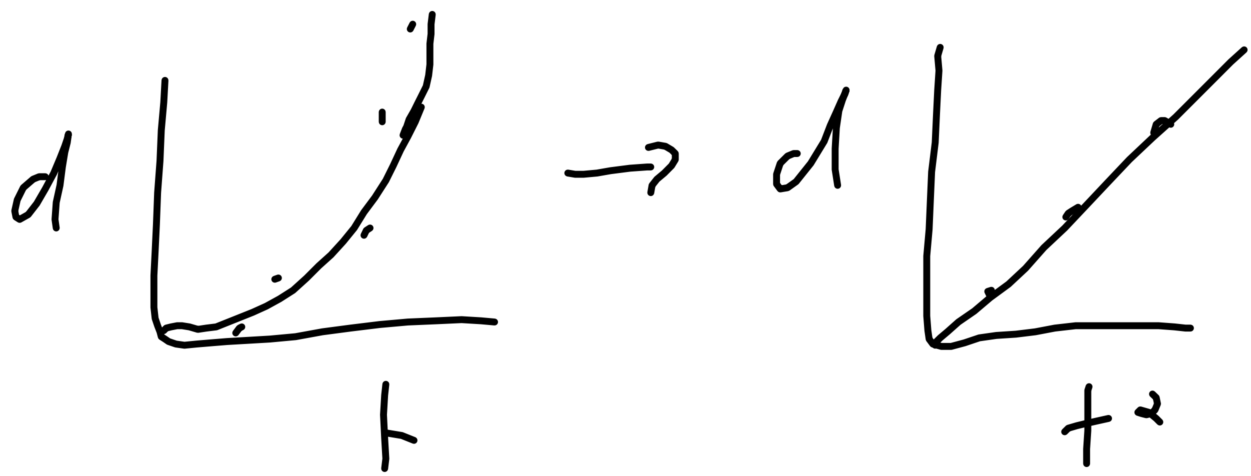
210 m
$2.1 \times 10^2\ m$

Graphing
purpose: Looking for trends - derive an equation

and look for other patterns

procedure:
collect data
label the graph and the axes,
determine the scale so that the graph takes up over half the page - scale should be consistent
plot points
draw a best-fit line - close to all the data and shows the trend (DO NOT CONNECT THE DOTS)
-if linear then determine slope and y-intercept and sub into y=mx+b
eg. F = 2.0 kg a + 0.12 N note sub in every term

if non-linear then make it straight by



regraph the data with transformed x values
eg. you can square or inverse all the x data to make it linear

Measurement, Accuracy, Precision, Patterns

Physics is an experimental enquiry.
Measurement is comparing an observation to a standardized value, unit.

Metric System
Base units:
length - metre, m
mass - kilogram, kg
time - seconds, s
Ampère, A electric current
Temperature, Kelvin, K
Candela, cd for light intensity

derived
volume - litre, l
gram, g
ml = cm^3
$(100\ cm)^3 = m^3 = 1\ 000\ 000 cm^3$

prefixes

Accuracy - How close to the accepted or theoretical value is a measurement.

In labs, we will quantify the accuracy as the %error.

%error = |experimental - theoretical|/theoretical x 100%

eg. look at a projectile and measure the acceleration due to gravity at 8.9 m/s^2. What is the percent error of that measurement?

theoretical = 9.80 m/s^2

%error = |8.9 - 9.8| /9.8 x 100% = 9.2 %

Precision - A measure of the range of values you get when you measure with a certain apparatus.

the smaller the range, the better the precision.

eg. you measure the width of a book at 14.0 cm while your partner measures at 16.5 cm. You might give the value in your data table as
15 cm , this implies an uncertainty of +/- 1 cm

while 15.0 implies +/- 0.1 cm uncertainty

Your choice of the number of digits to record is a way of specifying the uncertainty range.

the time on the clock is 12:40.04
analogue clock you would set the uncertainty at half the smallest division, or half a second.

digital stopwatch, the last digit is your uncertainty but your reaction time or anticipation time can make the measurement less precise than the reading.

5.02 s implies precision to the hundredth but using a stopwatch, you should only record 5.0s because of the reaction time.

Rules for Significant Digits or Significant Figures, Sig Figs or SF

all non-zeros are significant
zeros after numbers and after the decimal are significant
zeros in the front are not significant
zeros in the middle are significant

eg. how many sig figs are in:

235456	6
3.000	4
303.0	4
2.040×10^5	4
0.00034	2

200 1 or ask

2×10^2 or 2.0×10^2 or 2.00×10^2

Adding/subtracting

round the answer to the least precise decimal place

multiply/divide round the answer to the least number of significant digits

4sf 2sf 2sf

eg. 2.030cm x 0.13cm = $0.26\ cm^2$

2.030 cm +0.13cm =

$$\begin{array}{r} 2.030\ cm \\ +\ 0.13\ cm \\ \hline 2.160 \end{array} = \boxed{2.16cm}$$

Graphing

title, labels for axes, with units, even scale (data should take up over half the page), plot points, line of best-fit - close to all the data, shows the trend (DO NOT CONNECT THE DOTS),

linear - calculate slope and y-intercept (careful with sig figs), sub into y=mx+b

eg. F = 2.0 kg a + 0.12N

(careful with sig figs) sub into y=mx+b

eg. F = $\underline{2.0\ kg}$ a + 0.12N ⇐ y-intercept + units

y variable   slope + units   x variable

if non-linear = make it linear by transforming the data - eg. square the x-data or inverse the x-data

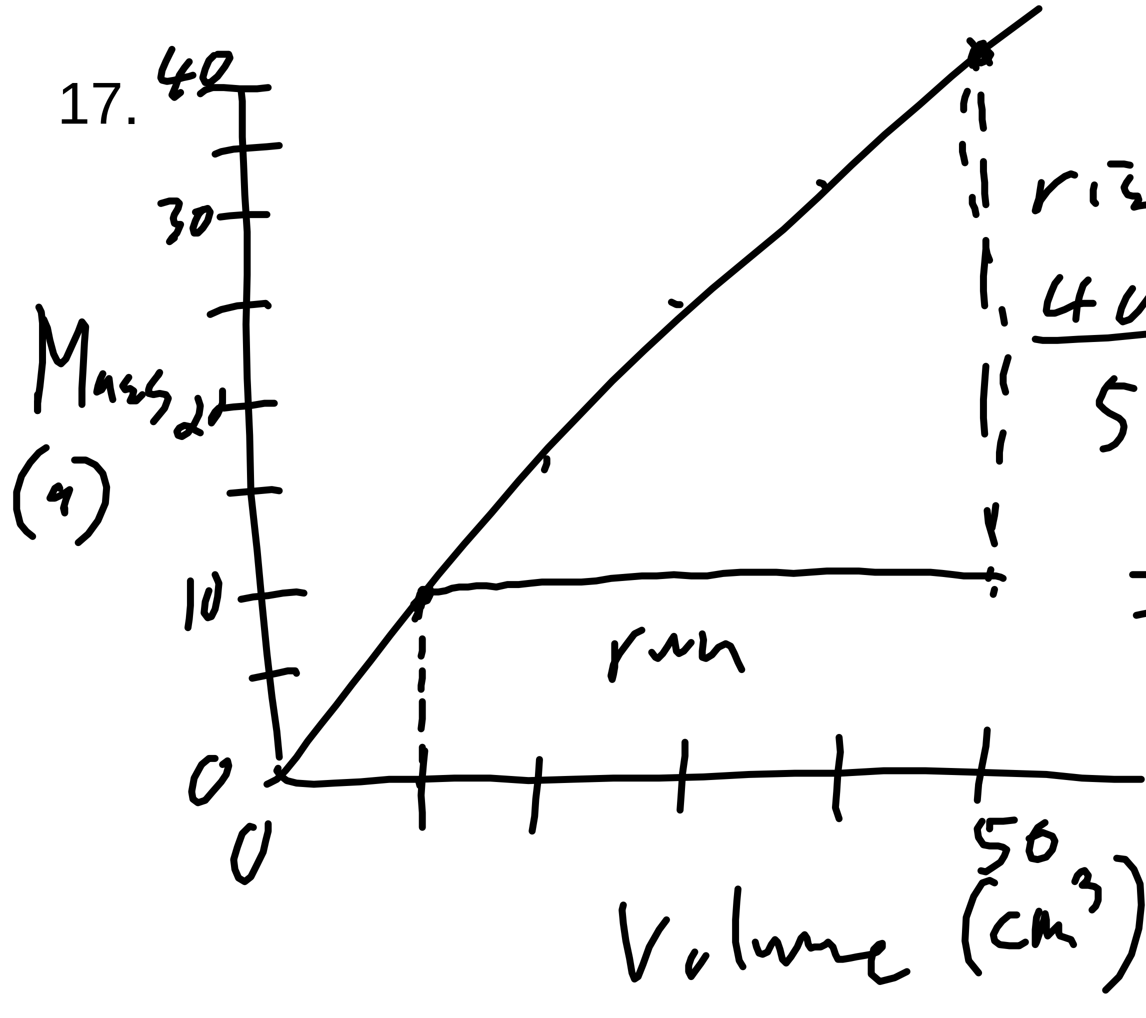
regraph and get an equation

Tuesday, September 15, 2015
8:42 AM

12a) 101.6 m - round to least pr. deci
b) 584 m^2 - round to lowest SFs.
33.21x17.6=584.496

16a) 400g, 275 g, 90 g
b) 8cm^3, 11 cm^3, 35 cm^3
c) density, the mass per unit volume, greater the slope, the denser the substance

17.



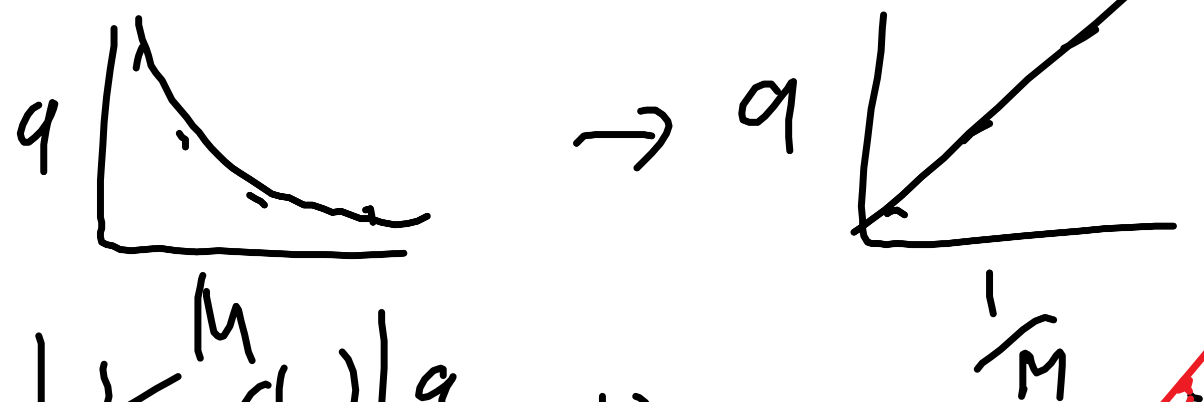
$$\frac{40-10\ g}{50-10\ cm^3} = \boxed{0.75 \frac{g}{cm^3}}$$

$$y = mx + b$$

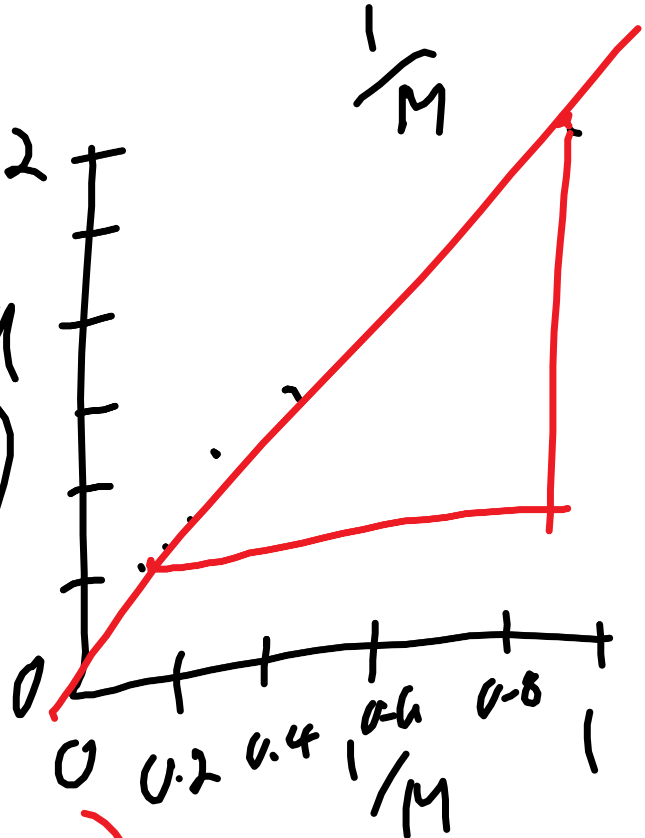
$y = mx + b$

$$\boxed{M = 0.75\,\frac{g}{cm^3}\,V + 1g}$$

19



M	1/M (1/kg)	a
1	1	12
2	0.5	5.4
3	0.33	4.1
4	0.25	3.0 (m/s²)
5	0.2	2.5
6	0.17	2.0



$$\text{Slope} = \frac{(12 - 2\ m/s^2)}{1 - 0.2\ 1/kg}$$

$$10\ kg\,m/s^2 = \boxed{12\ kg\,m/s^2}$$

$$= \frac{10}{0.8}\ kg\,m/s^2 = \boxed{12\ kg\,m/s^2}$$

$$y = mx + b$$

$$\boxed{a = 12\ kg\,m/s^2\ \frac{1}{M} \cancel{+0}}$$

12a) 101.6 m - round to least pr. deci

a) 584 m^2 - round to lowest SFs.

33.21x17.6=584.496

2SF

16.40m 4.5m 3.26m

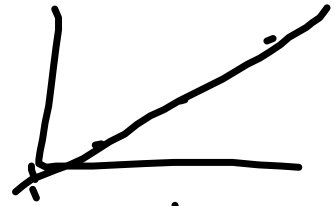
$$V = 16.40 \times 4.5 \times 3.26$$

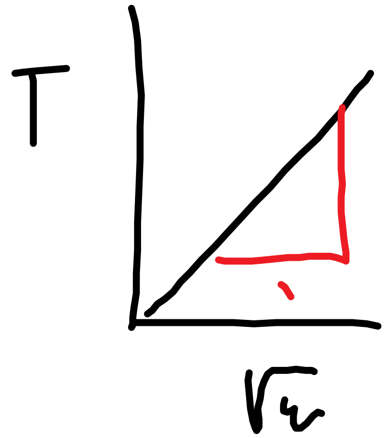
$$= \boxed{2.4 \times 10^2\ m^3}$$

Thursday, September 17, 2015
8:43 AM

Lab

$$T = \frac{2\pi}{\sqrt{K}} \sqrt{m}$$





$$\text{Slope} = 0.13 \frac{s}{\sqrt{kg}}$$

$$y = mx + b$$

$$T = 0.13 \frac{s}{\sqrt{kg}} \sqrt{m} + 0.15 s$$

experimental: $\text{slope} = 0.13 \frac{s}{\sqrt{kg}}$.

theoretical: $\frac{2\pi}{\sqrt{K}} = \frac{2\pi}{\sqrt{53 \,N/m}}$

$$= 0.86\sqrt{\frac{m}{k}}$$

$$= 0.86\sqrt{\frac{m}{k, N/s^2}} = 0.865\sqrt{}$$

$$\%\ error = \frac{|exp - th|}{th} \times 100\%$$

$$= \frac{|0.13 - 0.86|}{0.86} \times 100\%$$

$$= \underline{85\%\ error}$$

$$K = \frac{0.5\cancel{kg} \times 9.8\frac{N}{\cancel{kg}}}{0.050\,m} = \boxed{98\frac{N}{m}}$$

Kinematics Review

study of motion 1-d
types of motion:
constant velocity:
d=vt
d is displacement, the change in position, includes direction - a vector
v is velocity - the rate of change in position, m/s - vector
t is time, in seconds where d = 0 at t=0
slope of a d-t graph is velocity

Constant acceleration:
$v_f^2=v_i^2 + 2ad$
$d=1/2at^2 + v_it$ - the d-t graph is a parabola
$a=\Delta v/\Delta t$ or $v_f=at + v_i$ slope of a v-t graph = a
$d=1/2(v_i+v_f)t$ area under a v-t graph =d

acceleration is constant when force is constant. F=ma

If air resistance is negligible, then the acceleration due to gravity is constant near Earth at $9.80m/s^2$.

g is the gravitational field strength = 9.80N/kg

independent of mass

eg.

1. A car is moving at a constant 140 km/h past a police car at rest. 2.0 s later, the police car accelerates at 7.5m/s^2.

a) how fast is the speeding car in m/s?
b) how far did the car go in the 2.0s?
c) How long will it take for the police car to reach the same speed as the car?
d) How long(from when the car passes the police) before the police car catches the car?
e) where does the police car catch the car?

2. You throw a ball up in the air at 3.0 m/s from a height of 1.5m.

a) how high does it go?
b) what is the speed after 1.5s?
c) when does it hit the ground?

$T = 0.139\sqrt{m} + b$

$$T = \frac{0.139}{\sqrt{kg}} \sqrt{m} + b$$

$$0.93\,s = 0.13\frac{s}{\sqrt{kg}}\, 0.95\cancel{kg} + b$$

eg.

1. A car is moving at a constant 140 km/h past a police car at rest. 2.0 s later, the police car accelerates at 7.5m/s^2.

a) how fast is the speeding car in m/s?
140$\cancel{\text{km/h}}$ (1000m/$\cancel{\text{km}}$)($\cancel{\text{h}}$/3600s) = 38.9 m/s

b) how far did the car go in the 2.0s?
d=vt = 38.9 m/s x 2s = 77.7m = 78m

c) How long will it take for the police car to reach the same speed as the car?
$v_i = 0$ $v_f=38.9m/s$ $a=7.5m/s^2$ $t=?$
$v_f=at+v_i$
$38.9m/s = 7.5m/s^2 t + 0$
$t= 5.2$ s

d) How long before the police car catches the car?
police car: $v_i = 0$ $a=7.5m/s^2$ $t=0$ when car passes d=d
$d=1/2a(t-2)^2 + vi(t-2)$
speeding car $d=vt$
$ax^2 + bx + c = 0$
$x= [-b+/-root(b^2-4ac)] /2a$

e) where does the police car catch the car?

1. You throw a ball up in the air at 3.0 m/s from a height of 1.5m.

a) how high does it go?
b) what is the speed after 1.5s?
c) when does it hit the ground?

1. A car is moving at a constant 140 km/h past a police car at rest. 2.0 s later, the police car accelerates at $7.5 m/s^2$.

a) how fast is the speeding car in m/s?

$140 \cancel{k}m/\cancel{h}\ (1000m/\cancel{km})(\cancel{h}/3600s)$

$= 38.98\ m/s = 39\ m/s$

b) how far did the car go in the 2.0s?

$d=vt = 38.98m/s \times 2.0s = 78m$

c) How long will it take for the police car to reach the same speed as the car?

$v_f= 38.98m/s\ \ v_i =0\ \ a=7.5m/s^2\ \ t=?$

$v_f=at + v_i$

$38.98m/s = 7.5m/s^2\ t + 0$

$t= 38.98/7.5=5.1973 =5.2s$

d) How long(from when the car passes the police) before the police car catches the car?

d=vt car

$d=1/2a(t-2)^2 = 3.75(t^2 -14t +4) =d = 38.98\ t$

$vt=1/2a(t-2)^2$

$ax^2+bx +c=0 \quad x = \frac{-b\mp\sqrt{(b^2 -4ac)}}{2a}$

$3.75t^2 -91.48t +15 =0$

$t = (91.48+/- root(91.48^2-4(3.75)(15)))/2(3.75)$

$91.48+/- 90.242/7.5$

24.2s

e) where does the police car catch the car?
$d=vt=5.8 \times 10^2$ m from where the car passes the police
$d=1/2at^2 = 3.75(13s)^2 = 850m$ don't match, I messed up

1. You throw a ball up in the air at 3.0 m/s from a height of 1.5m.

a) how high does it go?
vi = 3.0m/s vf = 0 a = $-9.80m/s^2$ d
$vf^2 = vi^2 + 2ad$
d=9/(2x9.8) = 0.459m from the launch point or 1.959m from the ground = 2.0m height

b) what is the speed after 1.5s?
vf=? vi=3.0m/s t=1.5s a=$-9.80m/s^2$
vf=vi + at
= 3.0m/s + $-9.80m/s^2$(1.5s) = -11.7m/s =-12m/s

c) when does it hit the ground?
assuming the ground is 1.5m down
d=-1.5m a=$-9.80m/s^2$ vi=3.0m/s t=?
$d=1/2at^2 + vit$
$-1.5 = -4.9t^2 + 3t$
$0=-4.9t^2 +3t + 1.5$

-3+/- root(9-4(-4.9)(1.5))/2(-4.9)
(-3-6.197)/-9.8 = 0.9384s
0.94s

tup = vf-vi/a = -3/-9.8 = 0.3061
tdown $d=1/2at^2$ $1.959=1/2 -9.8 t^2$
tdown = 0.632 s
total time = 0.3061 +0.632=0.94s

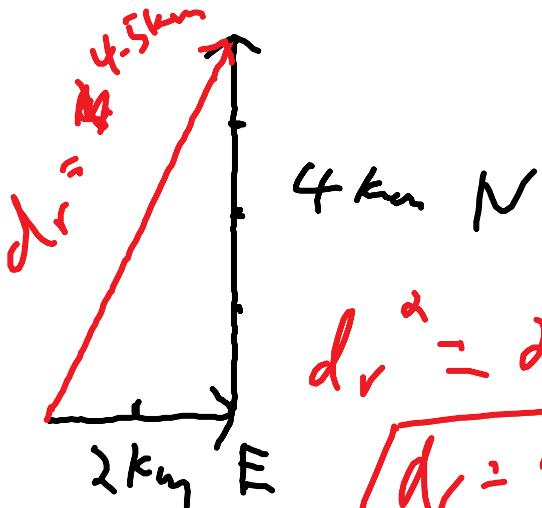
Addition of Vectors in 2-D

eg. you walk 2.0 km East then 4.0 km North. what is your a) distance travelled? b) displacement?

a) add the magnitudes because distance is a scalar quantity
   2+4=6 km

b) draw the vectors as arrows, head to tail

Scale 1cm = 1 km



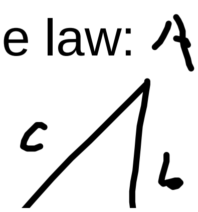
$d_r^2 = 2^2 + 4^2$

$\boxed{d_r = 4.5\text{ km}}$

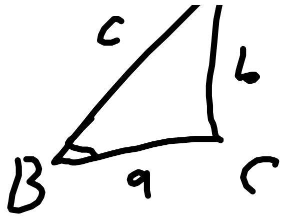
draw a resultant vector from the start to the end point

eg. you walk 2.0 km East, then 4.0 km 30.0º North of East. Determine the displacement using a scale vector diagram, cosine law, and vector components.

cosine law:

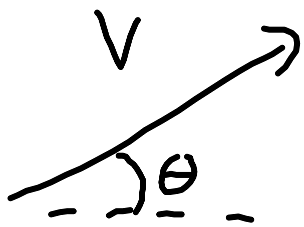


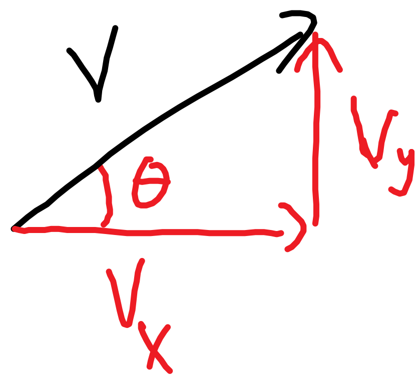
$c^2 = a^2 + b^2 - 2ab\cos C$



$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

Vector components: you take a vector at an angle and resolve it into two perpendicular vectors (like coordinates)





SOHCAHTOA

$$\sin\theta = \frac{V_y}{V}$$

$$\cos\theta = \frac{V_x}{V}$$

$$V_y = V\sin\theta$$

$$V_x = V\cos\theta$$

1. A car is moving at a constant 140 km/h past a police car at rest. 2.0 s later, the police car accelerates at 7.5m/s^2.

a) how fast is the speeding car in m/s?

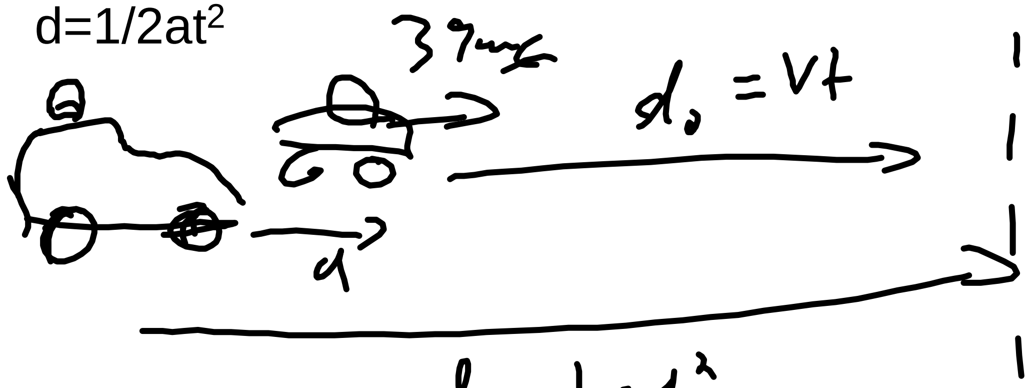
b) how far did the car go in the 2.0s?

c) How long will it take for the police car to reach the same speed as the car?

d) How long(from when the police starts) before the police car catches the car?

$d=v(t+2)$ car

$d=1/2at^2$



$d_1 = \frac{1}{2}at^2$

$d_1 - d_2 = 78 m$ $\quad \frac{1}{2}at^2 - vt = 78$

$3.75t^2 - 38.98t = 77.96$

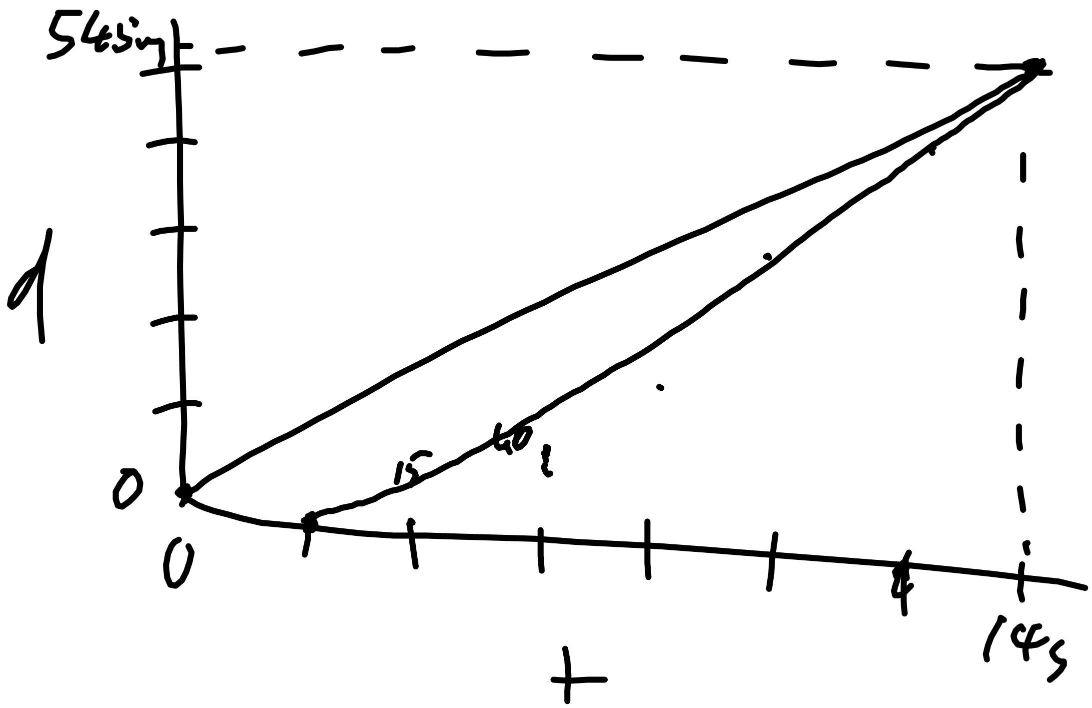
$3.75t^2 - 38.98t - 77.96 = 0$

$\frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{38.98 \pm \sqrt{38.98^2 - 4(3.75)(-77.96)}}{2(3.75)}$

$= \frac{38.78 \pm 51.85}{7.5} = 12.11 s$

$d = vt = 38.98 \times 12.11 =$

12 s from when the police car started chasing or 14s from when the car passed the police car.



e) where does the police car catch the car?
   =472 m = v × t = 38.98 × 12.11s =
   or d= 3.75m/s^2 (12.11)^2 = 549m

1. You throw a ball up in the air at 3.0 m/s from a height of 1.5m.

a) how high does it go?
   vi=3.0m/s vf=0 a=-9.80m/s^2 d=?
   vf^2 = vi^2 + 2ad
   d= 9/(2x9.8)=0.4592 =0.46m above the launch point
   or +1.5m = 1.96m 2.0m above the ground

b) what is the speed after 1.5s?
   vf=? vi=3.0m/s a=-9.80m/s^2 t=1.5s

   vf = 3+(-9.8x1.5)=-11.7 = -12m/s
   12m/s down

c) when does it hit the ground?
   $t_{up} = v_f - v_i/g = -3m/s / -9.8 m/s^2 = 3/9.8 = 0.3061$ s
   tdown = ? $d = 1/2at^2$ $-1.96m = -4.9 m/s^2\ t^2$
   t=root 1.96/4.9=0.4
   tdown=0.63s
   t total = tup + tdown = 0.3061s + 0.63s= 0.94s

   or you can solve in one step as a quadratic
   $d = 1/2at^2 + v_i t$
   $-1.5m = -4.9 m/s^2\ t^2 + 3m/s\ t$
   $-4.9t^2 + 3t + 1.5 = 0$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-3 \pm \sqrt{3^2 - 4(-4.9)(1.5)}}{2(-4.9)}$$

   = 4x4.9x1.5=29.4 29.4+9=38.4

   (-3 +/-6.196)/-2(4.9)
   0.94s

   Vector Addition

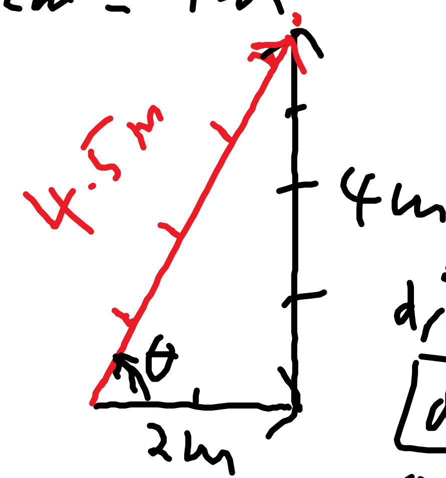
   A vector is a quantity with magnitude and direction.
   How do you add vectors?

   eg. you walk 2.0 m East, then 4.0 m North. what is your
a) distance travelled? b) displacement?

a) add the magnitudes, 2+4=6 m
b) draw the vectors as arrows, head to tail
   (subtract, just flip the direction of the vector)

Scale 10cm = 1m

Scale 10cm = 1m

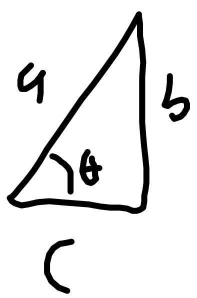


$d_r^2 = 2^2 + 4^2$

$\boxed{d_r = 4.5m}$

$\theta = \tan^{-1}\frac{4}{2} = \boxed{63^\circ \text{ N of E}}$

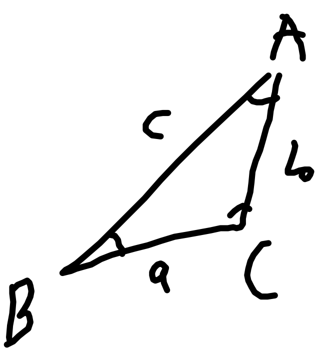
resultant vector is from the tail of the first vector
to the head of the last vector.



$a^2 = b^2 + c^2$

SOH CAH TOA

$\sin\theta = \frac{b}{a}$ $\cos\theta = \frac{c}{a}$ $\tan\theta = \frac{b}{c}$



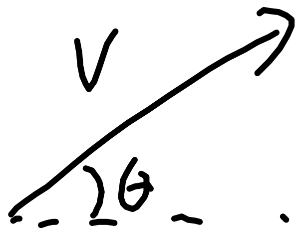
$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

$a^2 = b^2 + c^2 - 2bc\cos A$

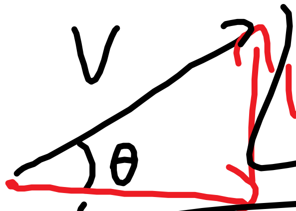
Vector Components:

- a vector can be represented

- a vector can be represented as the sum of 2 perpendicular vectors, called components (coordinat)



→



$$\boxed{V_y = V\sin\theta}$$

$$\boxed{V_x = V\cos\theta}$$

$$\sin\theta = \frac{V_y}{V}$$

$$\cos\theta = \frac{V_x}{V}$$

eg. you walk 2.0 m East and then 4.0m 30.0º North of East. What is your displacement?
solve using:

a) scale vector diagram (use a protractor)
b) cosine and sine laws
c) vector components

block 1-3

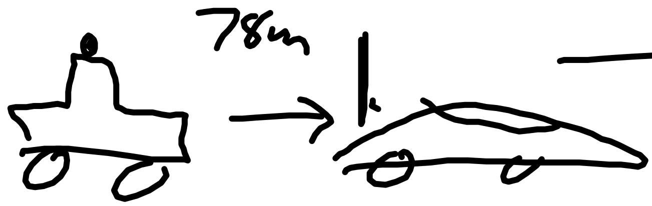
1. A car is moving at a constant 140 km/h past a police car at rest. 2.0 s later, the police car accelerates at 7.5m/s^2.

a) how fast is the speeding car in m/s?

b) how far did the car go in the 2.0s?

c) How long will it take for the police car to reach the same speed as the car?

d) How long(from when the car passes the police) before the police car catches the car?



$d_c = vt$

78m

$t=0$

$d_p = \frac{1}{2}at^2 = vt + 2v$

$3.75t^2 = 38.98t + 77.8$

$ax^2 + bx + c = 0$

$3.75t^2 - 38.78t - 77.8 = 0$

$\frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$$\frac{38.78 \pm \sqrt{38.78^2 - 4(3.75)(-77.8)}}{7.5}$$

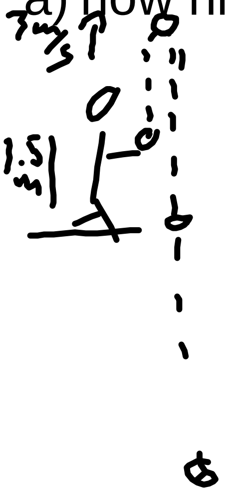
$= 12.1s$ from when the Police starts

14s from when the car passes the police.

~~a)~~ where does the police car catch the car?
→ d=vt = 38.98x14.11=550m
d= (0.5x7.5x12.11x12.11)=549.9454 =550m

1. You throw a ball up in the air at 3.0 m/s from a height of 1.5m.

a) how high does it go?



$d = ?$ $\quad V_i = 3\ m/s$

$V_f = 0$ $\quad a = -9.80\ m/s^2$

$$V_f^2 = V_i^2 + 2ad$$

$$0 = 9\ m^2/s^2 + 2(-9.8\ m/s^2)d$$

$$d = 0.46\ m$$

0.46m above launch point or
2.0m above the ground.

b) what is the speed after 1.5s?
vf=vi + at = 3+(-9.8x1.5)=-11.7 =-12m/s
12m/s down

c) when does it hit the ground?

2-D Vectors

1. You walk 2.0 m East then 4.0m. What is your distance travelled and displacement if
a) you walk 4.0m North
b) you walk 4.0m 30.0º North of East.

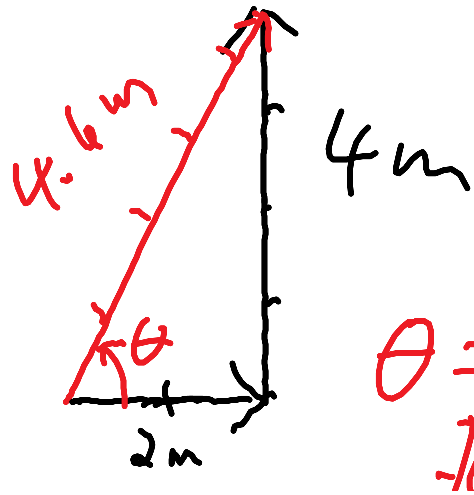
solve using a scale vector addition diagram, trig, use vector components.

distance travelled is a scalar so it is always the sum of the magnitudes, 2+4=6 m

displacement is a vector, so you need to include direction.

Add vectors, draw them as arrows head to tail. (subtraction, just reverse the direction of the vector)

Scale 10cm = 1m



$$d_r = \sqrt{2^2 + 4^2}$$

$$= \boxed{4.5\ m}$$

$$\theta = \tan^{-1}\frac{4}{2} =$$

$\boxed{63^\circ \text{ N of E}}$

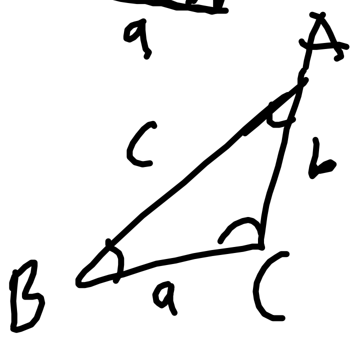
2m

G3 N, f E

Draw the resultant vector from the tail of the first vector to the head of the last vector.

$c^2 = a^2 + b^2$

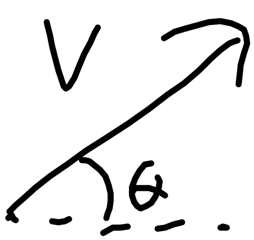
SOH CAH TOA



$c^2 = a^2 + b^2 - 2ab\cos C$

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

Vector components:
Any vector can be represented as the vector sum of 2 perpendicular vectors, called components.
Like coordinates of a graph.



$\rightarrow$

$V_y = V\sin\theta$

$V_x = V\cos\theta$

$$\sin\theta = \frac{V_y}{V}$$

$$\cos\theta = \frac{V_x}{V}$$

$t=0$

$78\text{m} = v \times 2\text{s}$

$v_i = 0$

$d_s = vt$

$a = 7.5\,\text{m/s}^2$

$t_d = 2.0\text{s}$

$d_p = \frac{1}{2}at^2 + \cancel{v_i t}^{\,0}$

$$\frac{1}{2}at^2 = vt + 78\text{m}$$

$$0 = -\frac{1}{2}(7.5)t^2 + 38.9t + 78$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = 12.1\text{s}$$

from when police starts

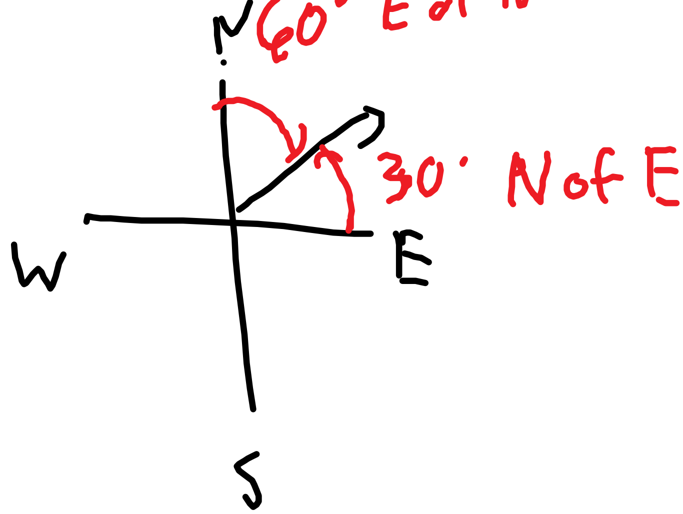
or $+2\text{s} = 14.1\text{s}$ from when the car passes the police

$$d = vt = 38.9\,\text{m/s}\,(14.1\text{s}) = \underline{540\text{m}}$$

$$d = \frac{1}{2}at^2 = \frac{1}{2}(7.5)(12.15)^2 = \underline{540\,m}$$

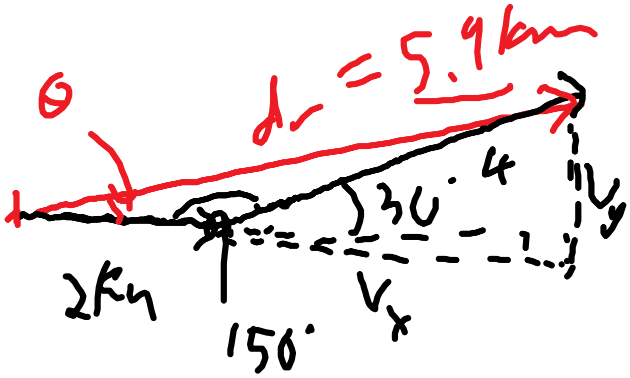
$$T = 1.1\,\frac{s}{\sqrt{kg}}\sqrt{m} + 0.1\,s$$

eg. you walk 2.0 km East, then 4.0 km 30.0º North of East. Determine the displacement using a scale vector diagram, cosine law, and vector components.



$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$d_r^2 = 2^2 + 4^2 - 2(2)4\cos 150$$



$$d_r = \boxed{5.8\text{ km}}$$

$$\frac{\sin\theta}{4} = \frac{\sin 150}{5.8}$$

$$\theta = \boxed{20^\circ \text{ N of E}}$$

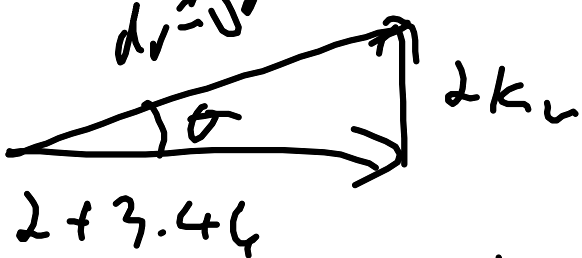
2 km E → 0 V_y, 2 km V_x

4 km 30° N of E

$V_y = 4\sin 30$
$= 2$ km

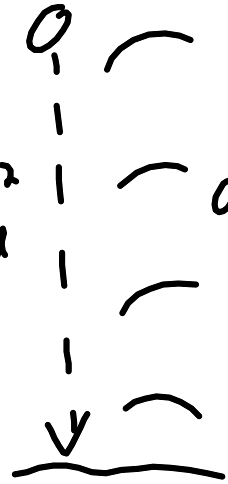
$V_x = 4\cos 30$
$= 3.46$ km

$$d_r = \sqrt{2^2 + 5.46^2} = \boxed{5.8\text{ km}}$$



$$\theta = \tan^{-1}\frac{2}{5.46} = \boxed{20^\circ}$$

$d = \frac{1}{2} g t_d^2$



$d = v_s t_{up}$

$t_d + t_{up} = 3.0\,s$

block 1-2

$$T = 1.1 \frac{s}{\sqrt{kg}} \sqrt{m} + 0.13\,s$$

$$T = 0.013 \frac{s}{m} A + 0.63\,s$$

Q27 p39

$v = 50\,km/h = 13.89\,m/s$

30m

12m

1. Brakes $a = -6.0\ m/s^2$

2. guns it $a = \frac{80km - 50km/h}{7s\ (3.6)} = 0.786\ m/s^2$

1. $V_f = 0$ $V_i = 13.89\ m/s$ $a = -6\ m/s^2$

$d = ?$ $d = \frac{V_f^2 - V_i^2}{2a}$

$$d = \frac{0 - (13.89)^2}{2 \times 6} = \underline{16.1m}$$

she can stop

Guns it:

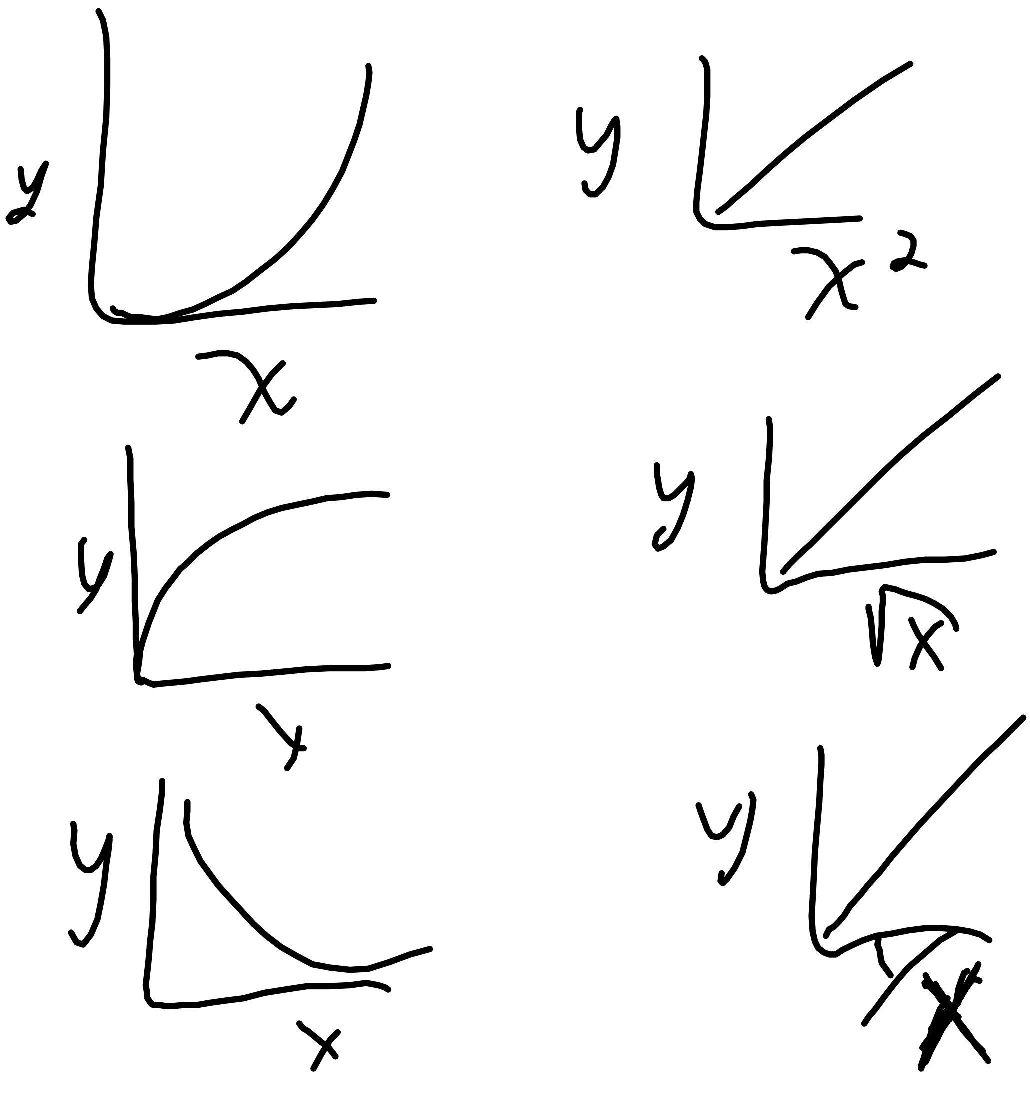
$a = 0.786\ m/s^2$ $t = 2.0s$

$V_i = 13.89\ m/s$ $d = ?$

$d = \frac{1}{2}at^2 + V_i t$

$= \frac{1}{2}(0.786)(2)^2 + 13.89(2) = \underline{29m}$

No



eg. you walk 2.0 m East and then 4.0m 30.0º North of East. What is your displacement?

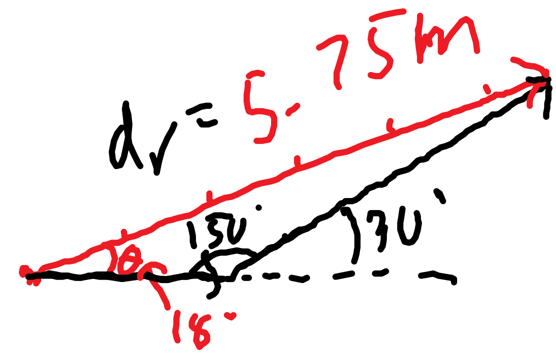
solve using:

a) scale vector diagram (use a protractor)

b) cosine and sine laws

c) vector components

a)



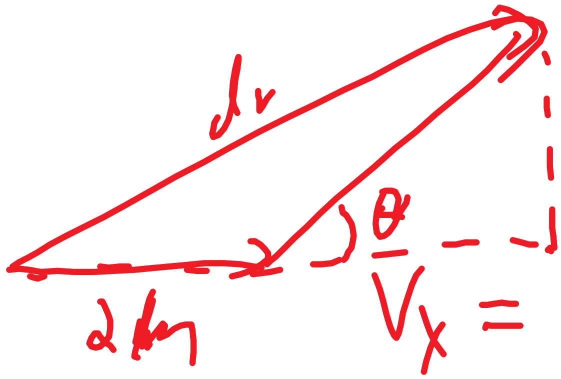
b) $a^2 = b^2 + c^2 - 2bc\cos A$

$d_r^2 = 2^2 + 4^2 - 2(2)(4)\cos 150°$

$\boxed{d_r = 5.8m}$

$\frac{\sin 150}{5.8} = \frac{\sin \theta}{4}$

$$\boxed{\theta = 20^\circ \text{ N of E}}$$



$V_y = 4\sin 30$
$= 2 \text{ m}$

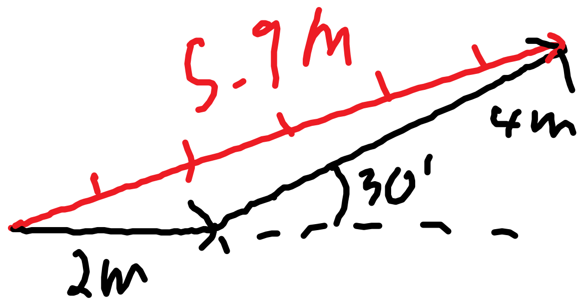
$V_x = 4\cos 30 = 4\sqrt{3}/2$
$= 3.46$

$$d_r = \sqrt{V_y^2 + (V_x + 2)^2}$$

$$d_r = \sqrt{2^2 + (2 + 3.46)^2} = \boxed{5.8 \text{ m}}$$

$$\theta = \tan^{-1}\frac{2}{5.46} = \boxed{20^\circ \text{ N of E}}$$

Scale 10cm = 1m   1:10

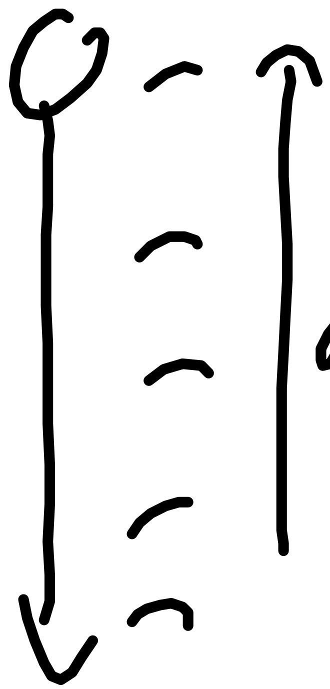

5.9m
4m
30'
2m

Friday, September 25, 2015
9:44 AM

Quiz - wow, took 55 minutes

p60 Questions 2,4, 5
Problems 1-7 odds, 15, 17

$v_i = 0$



d

$d = v_s t_{up}$

$d = \frac{1}{2} g t_d^2$

$t_d + t_{up} = 3s$

$$\sqrt{\frac{2d}{g}} + \frac{d}{v_s} = 3s$$

p60 Questions 2,4, 5
Problems 1-7 odds, 15, 17

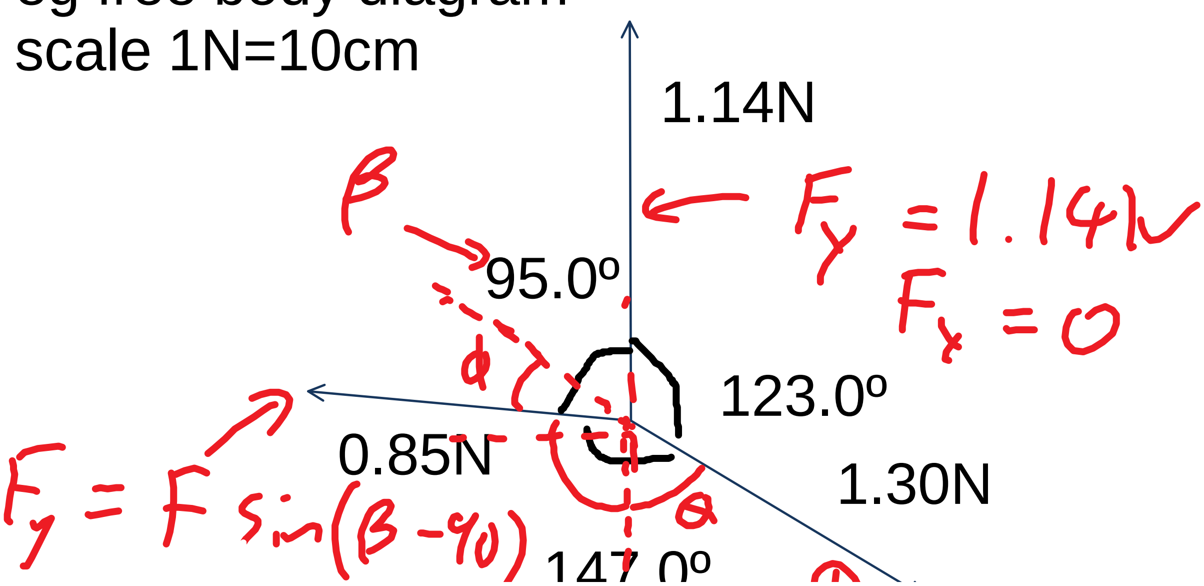
Tuesday, September 29, 2015
8:53 AM

3 Forces Lab Activity
No report

1- zero 3 force scales
2- connect them to each other on a board with paperclips
3- record the 3 forces and direction as a free body diagram (show the forces) - change and repeat for each group member

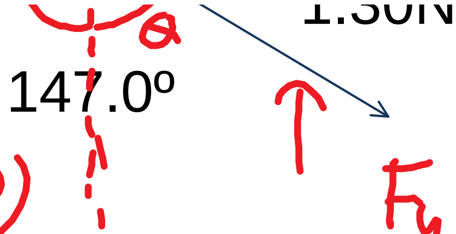
4- draw the free body diagram to scale
5- on the back draw a vector addition diagram to scale - watch the directions.
6- calculate the components of each vector relative to the first vector you draw
7- Add the components and calculate the resultant and compare to the diagram (%error). Show calculations of components and % error on the vector addition diagram sheet.

eg free body diagram
scale 1N=10cm



$F_y = F\sin(\beta - 90)$

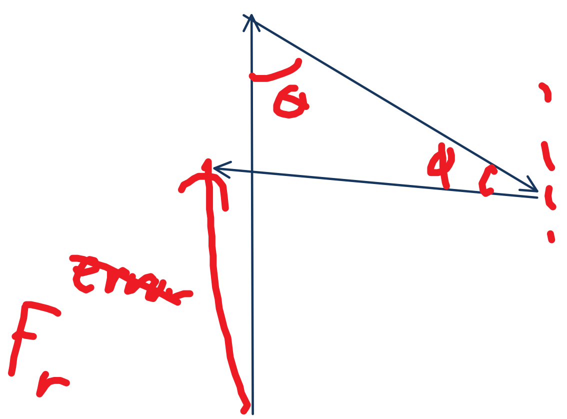
$F_x = F\cos(\beta - 90)$

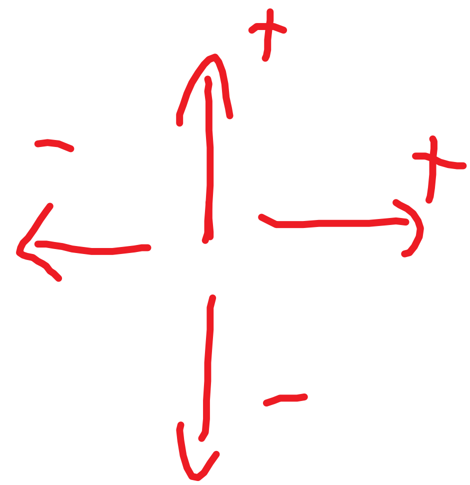


$F_y = F\cos\theta$

$F_x = F\sin\theta$

vector addition diagram:





$$F_{y_1} + F_{y_2} + F_{y_3} = F_{y\,total}$$

$$F_{x_1} + F_{x_2} + F_{x_3} = F_{x\,total}$$

- Negative if opposite directions

$$\sqrt{F_{y\,total}^2 + F_{x\,total}^2} = F_r$$

$F_{r1} - F_{r}$...

$$\sqrt{F_{y\,total}^2 + F_{x\,total}^2} = F_r$$

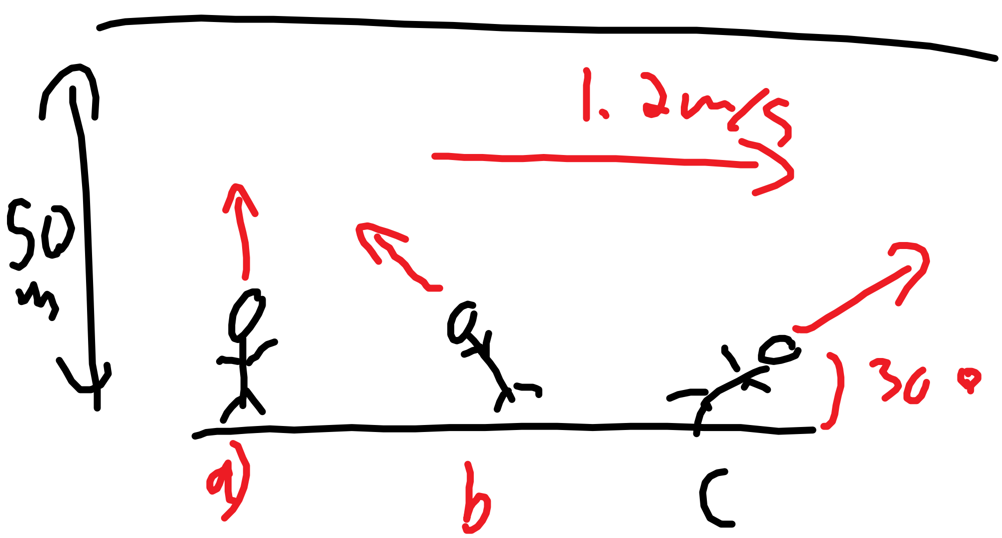
$$\%\ error = \frac{F_{rd} - F_{rc}}{F_{rc}}$$

eg. You swim at 2.00 m/s in a river flowing at 1.20m/s. If you want to cross the river, how long does it take if you: - if the river is 50.0 m wide

a) point right across

b) point upstream so you end up directly across

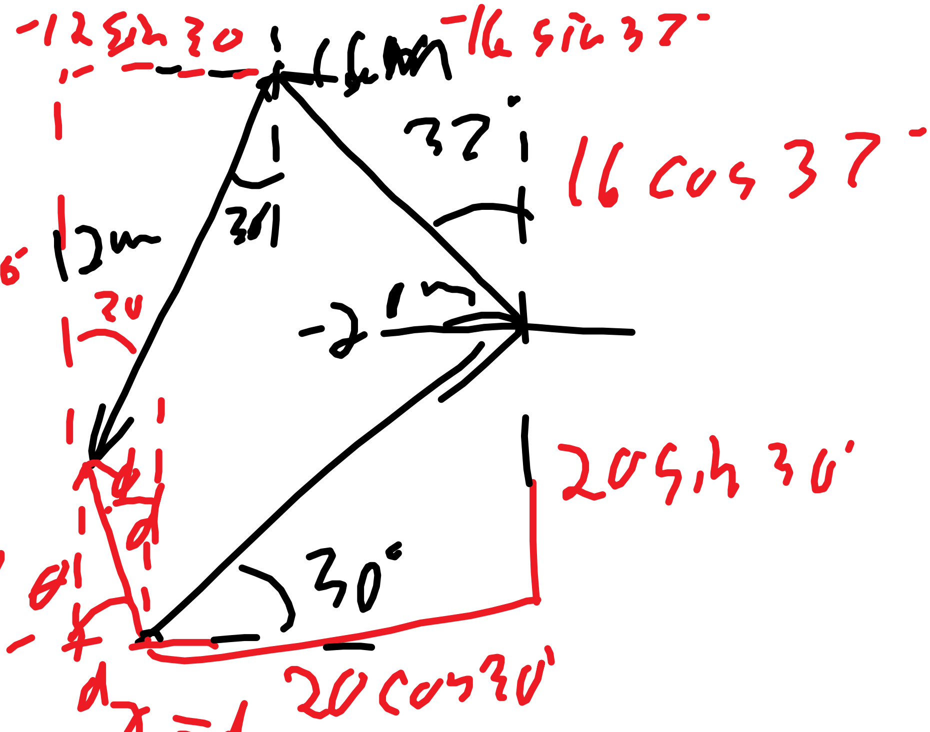
c) point at 30.0º to the shore downstream



$-1.2 \sin 30$ $-16 \sin 37$

Block 1-2

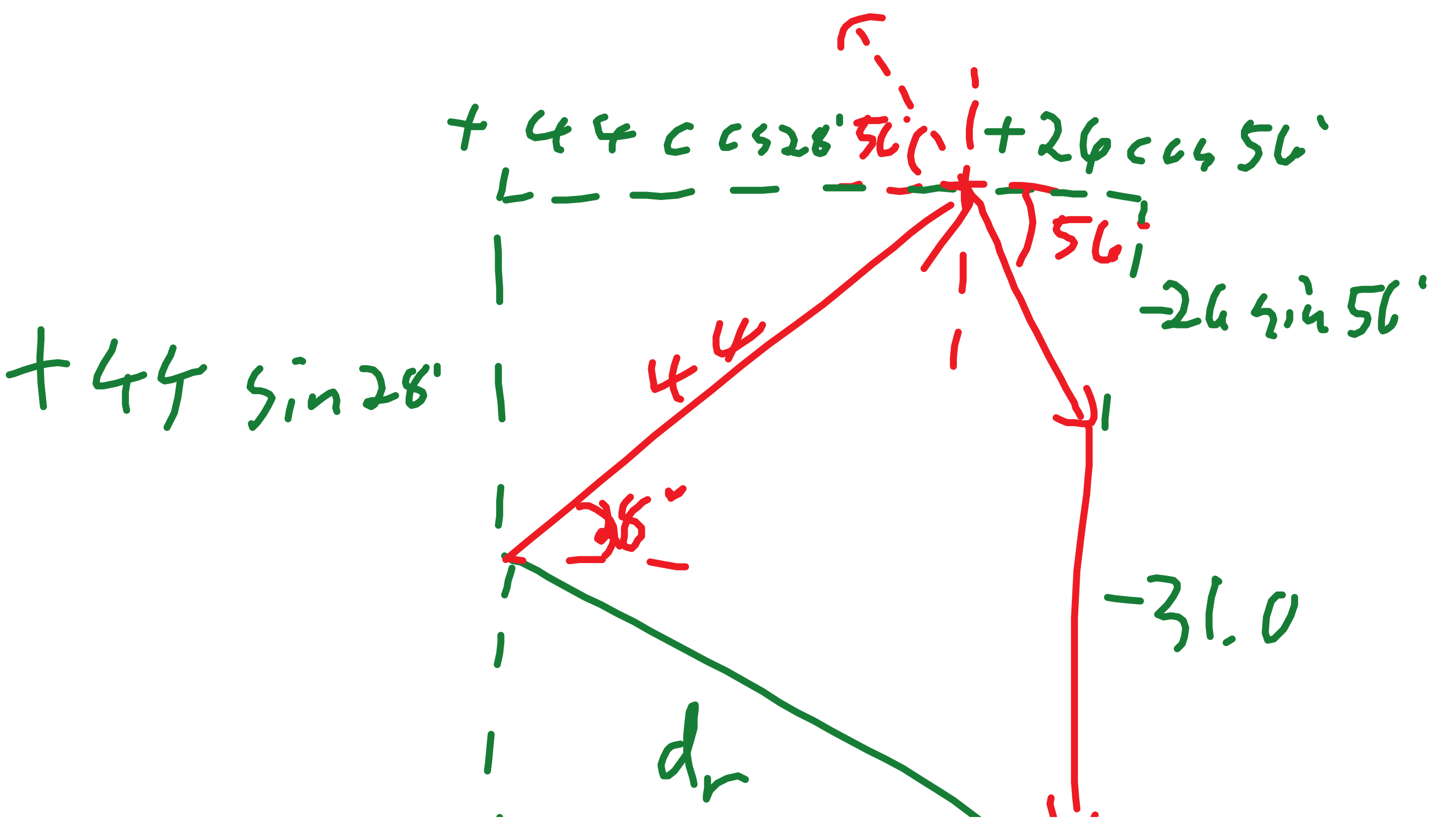
p61
Problem 7



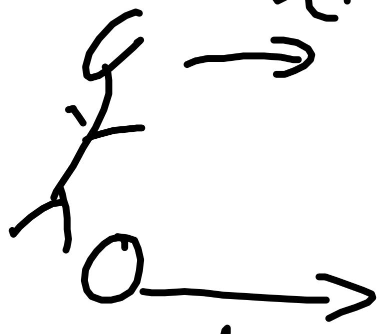
$d_{y_1}+d_{y_2}+d_{y_3}=d_y$

$d_x=d_{x_1}+d_{x_2}+d_{x_3}$

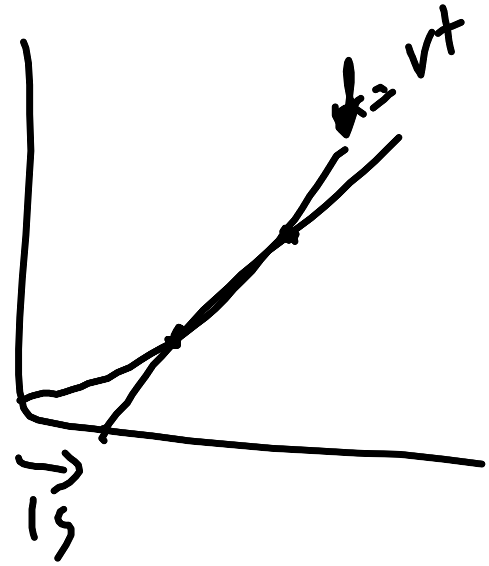
$d=\sqrt{d_y^2+d_x^2}$ $\qquad$ $\theta=\tan^{-1}\dfrac{d_y}{d_x}$



$$d = v(t-1)$$

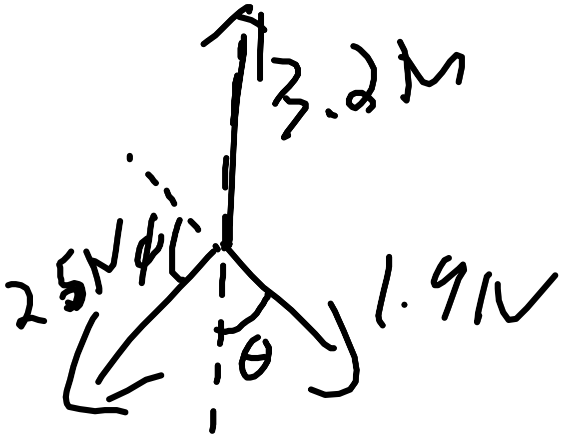


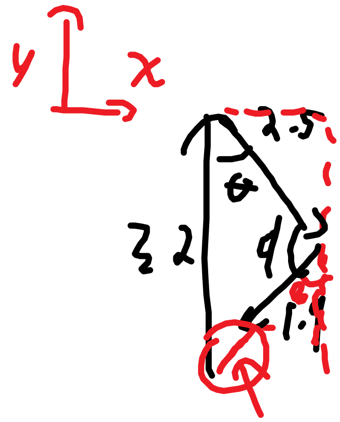
$$d = \frac{1}{2}at^2 + v_i t$$



$$v(t-1) = \frac{1}{2}at^2 + v_i t$$

Wednesday, September 30, 2015
3:13 PM





$F_1 \sin\theta$

$F_1 \cos\theta$

$F_2 \sin\beta$

$F_2 \cos\beta$

Quiz:

1a) 3 sf, m^2

$$
\begin{array}{r}
0.0076\ \text{kg} \\
+\ 0.07001\ \text{kg} \\
\hline
\boxed{0.0776\ \text{kg}}
\end{array}
$$

1.7004 ms

ms

1.64 ms

+ 9.76 ms

11.40 ms

a) $V_f = V_i + at$ 7.0 m/s or 6.6 m/s

b) $d = \frac{1}{2}(v_i + v_f)t$ 3.3 s or 3.6 s

$d = \frac{1}{2}at^2 + v_i t$

c)

$d = v(t-1)$

$$\frac{1}{2}at^2 + v_i t = V(t-1)$$

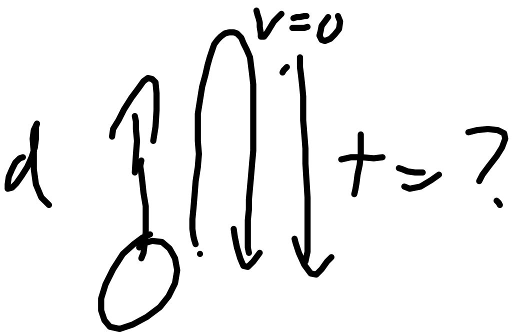
$$d = v(t-1) = 4.7\,m \text{ or } 35\,m$$

5.0 m or

$$\frac{1}{2}(3)t^2 + 1 \times t = 10(t-1)$$

$$1.5t^2 - 9t + 10 = 0$$

$t^2 - 8t + 16 = 0$



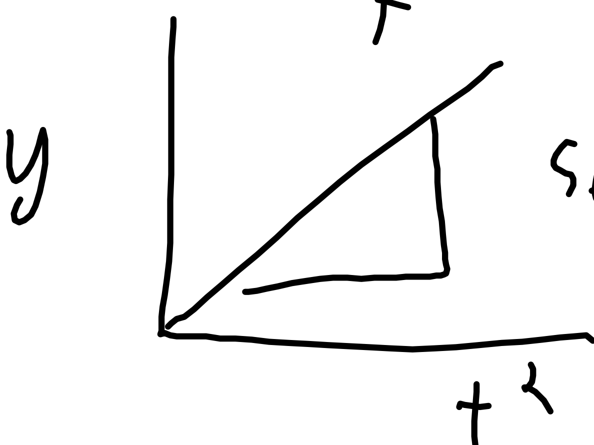
$d = \frac{1}{2} a t_{down}^2$

$a = -9.80 \, m/s^2$

$t_d = \sqrt{\frac{2d}{9.8}}$

$t = 2t_d = 1.5 \, s$
or $1.8 \, s$

$\frac{1}{1}$



slope $= 1.0 \, m/s^2$
$= 4.0 \, m/s^2$

$\boxed{y = 1.0 \, m/s^2 \, t^2}$

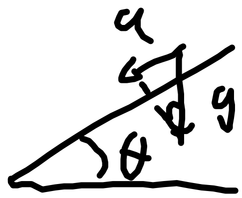
$d = \frac{1}{2} a t^2$

$d = \frac{1}{2} a t^2$

$\boxed{y = 4.0\,\mathrm{cm/s^2}\, t^2}$

$a = 2\,\text{slope}$

$= 2\,\mathrm{m/s^2}$ or $8\,\mathrm{m/s^2}$



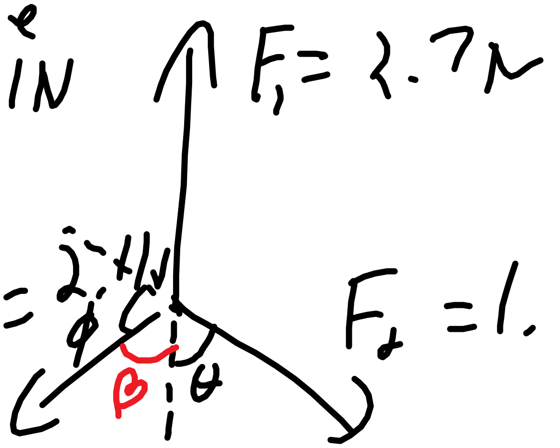
$a = g \sin\theta$

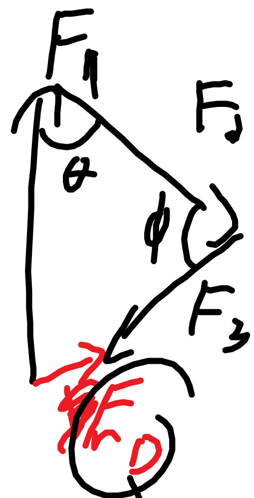
Scale
10cm = 1N

$F_1 = 2.7N$

$F_3 = 2.4N$

$F_2 = 1.7N$





Free body

Vector Add.

$\cancel{F_{1x}}^{\,0} + F_2 \sin\theta + F_3 \sin\beta = F_{rx}$

$F_{1y} + F_2 \cos\theta + F_3 \cos\beta = F_{ry}$

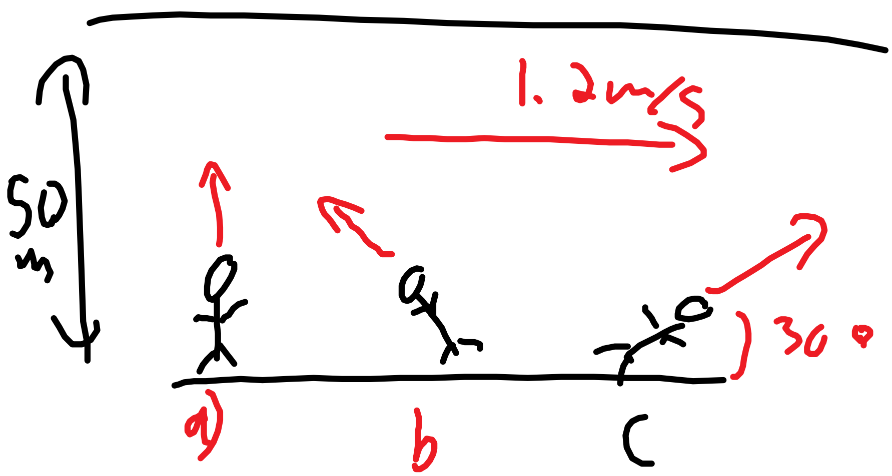
$F_r = \sqrt{F^2 + F^2}$

$\%\,\text{error} = \frac{F_p - F_c}{F_c} \times 100$

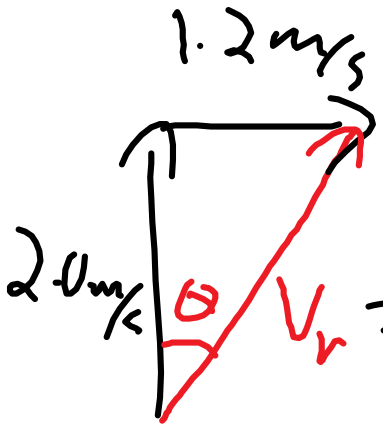
$$F_{r_c} = \sqrt{F_{r_x}^2 + F_{r_y}^2}$$

eg. You swim at 2.00 m/s relative to the water in a river flowing at
1.20m/s. If you want to cross the river, how long does it take if you: - if the river is 50.0 m wide

a) point right across
b) point upstream so you end up directly across
c) point at 30.0º to the shore downstream



a)



$$V_r = \sqrt{2^2 + 1.2^2} = \boxed{2.3\ m/s}$$

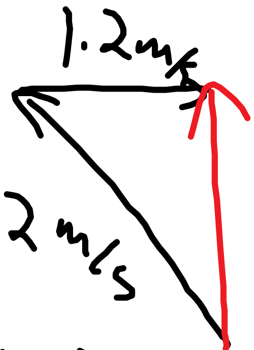
$$\theta = \tan^{-1}\frac{1.2}{2.0} = \boxed{31°}$$

from original

b) 1.2 m/s

from original direction

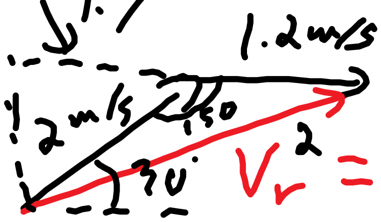
b)



$$V_r = \sqrt{2^2 - 1.2^2} = 1.6\ \text{m/s}$$

$v_x = 2\cos 30° = 1.7$

c)



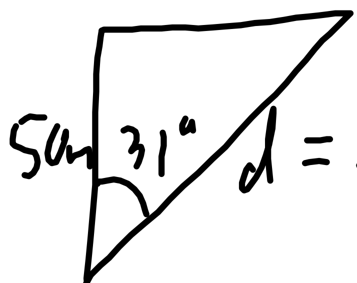
$v_y = 2\sin 30 = 1\ \text{m/s}$

$$V_r^2 = 2^2 + 1.2^2 - 2(2)(1.2)\cos 150$$

$$V_r = 3.1\ \text{m/s}$$

$$V_r = \sqrt{1^2 + (1.7+1.2)^2} = 3.1\ \text{m/s}$$

a) $t = \frac{d}{v}$



$\cos 31° = \frac{50}{d}$

$d = \frac{50}{\cos 31°} = 58\ \text{m}$

$$= \frac{58\ \text{m}}{2.3\ \text{m/s}} = \boxed{25\ \text{s}}$$

or $t = \frac{d_y}{V_y} = \frac{50\ \text{m}}{2\ \text{m/s}} = \boxed{25\ \text{s}}$

b) $t = \frac{d}{\ } = \frac{50\ \text{m}}{\ } = \boxed{21\ldots}$

b) $t = \frac{d}{v} = \frac{50\,m}{1.6\,m/s} = \boxed{31\,s}$

c) $t = \frac{d_y}{v_y} = \frac{50\,m}{1\,m/s} = \boxed{50\,s}$

Block 1-2
Quiz:

a) 3sfs, m^2
b) least precise decimal place

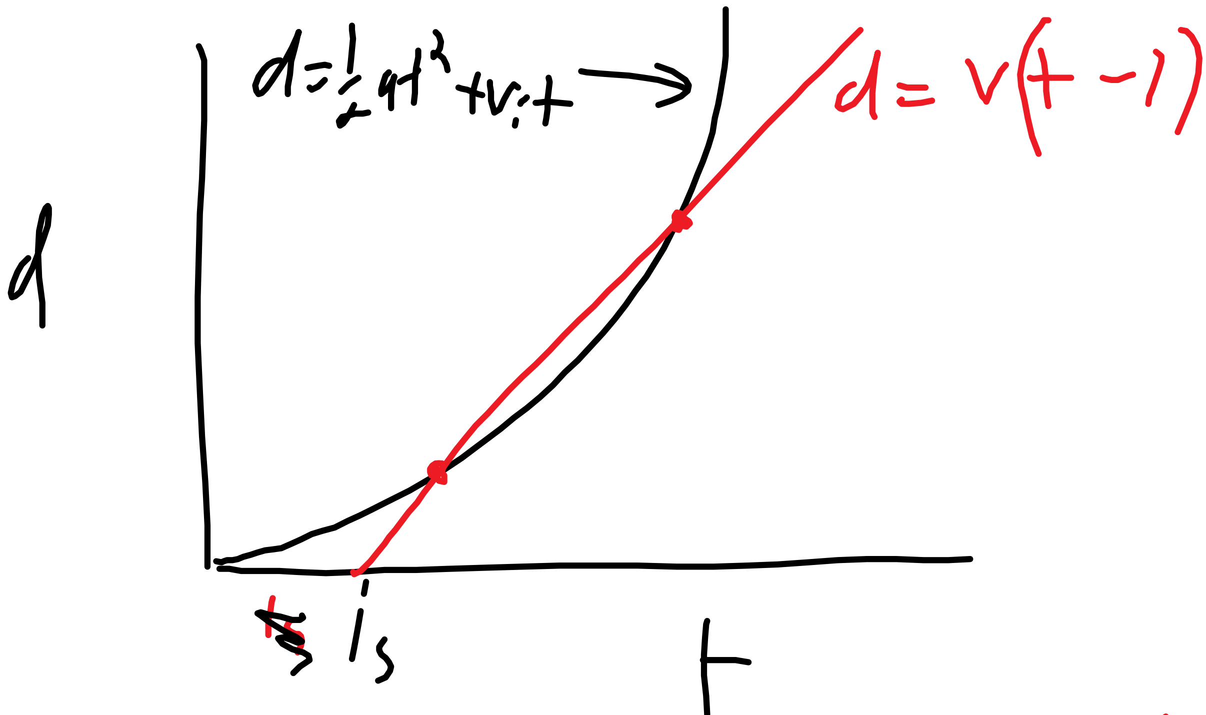
$$\begin{array}{r} 0.00056 \\ +\,0.06001 \\ \hline 0.06057 \end{array}$$

5.88×10^5

588 $\underline{000}$ unclear

d)
$$\begin{array}{rl} 1.5004 & ms \\ +\,9.90 & ms \\ \hline \boxed{11.40\ ms} & \end{array}$$

$\boxed{11.40 \text{ m/s}}$



a) $v_f = v_i + at$ $= 7.0 \text{ m/s}$ or 6.0 m/s

b) $d = \frac{1}{2}(v_i+v_f)t$ $t = 3.3\text{ s}$ or 3.6 s

c) $\frac{1}{2}at^2 + v_it = v(t-1)$

$1.5t^2 - 9t + 10 = 0$

$t^2 - 8t + 10 = 0$

$d = 4.7\text{m}$ 35m

$= 5.5\text{m}$

54m

d) $v=0$ d $+d$ ~~$d=0$~~

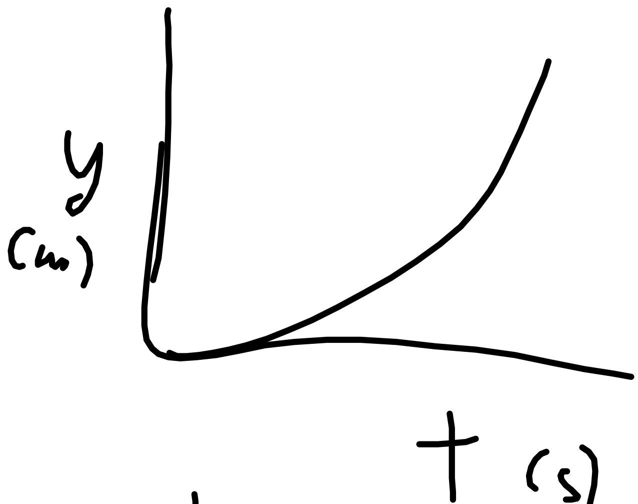
$v_i = 0$

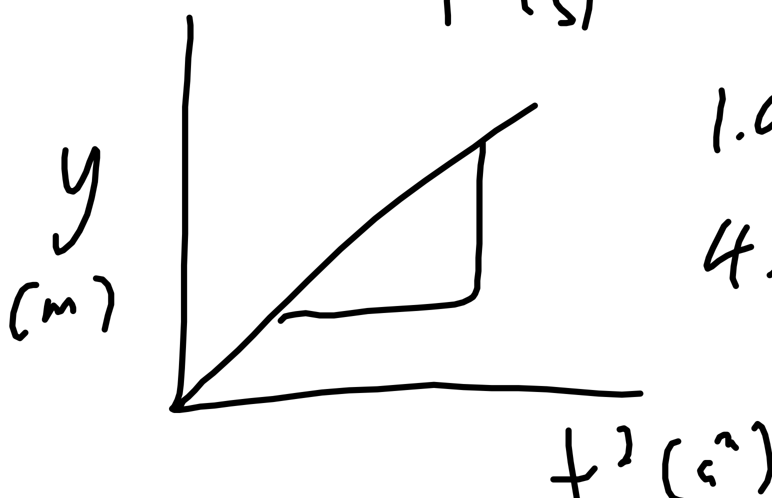
$\cancel{0 = \frac{1}{2}at^2}$

$d = \frac{1}{2}at_d^2$

$t = 2t_d$

$t = 1.55$ 1.85





1.0 m/s²

4.0 m/s²

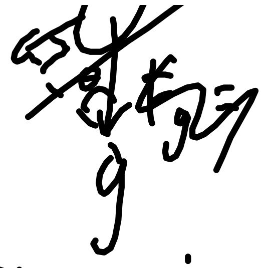
$$\boxed{y = 1.0\,m/s^2\,t^2}$$

4.0 m/s²

bonus

$d = \frac{1}{2} a t^2$

↑ slope



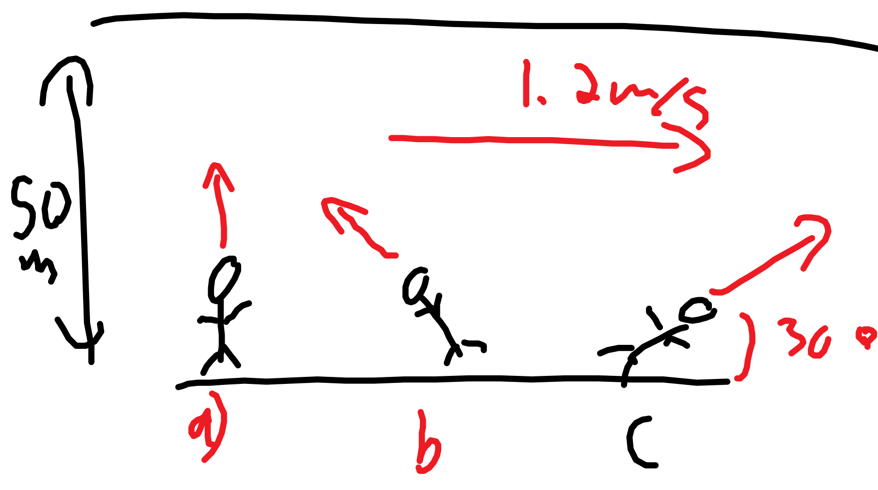
$a = g \sin\theta$

eg. You swim at 2.00 m/s in a river flowing at 1.20m/s. If you want to cross the river, how long does it take if you: - if the river is 50.0 m wide

a) point right across

b) point upstream so you end up directly across

c) point at 30.0º to the shore downstream

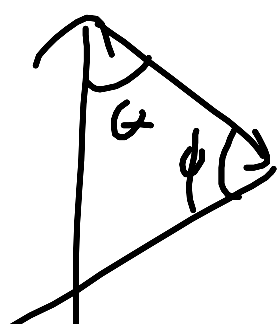


Lab

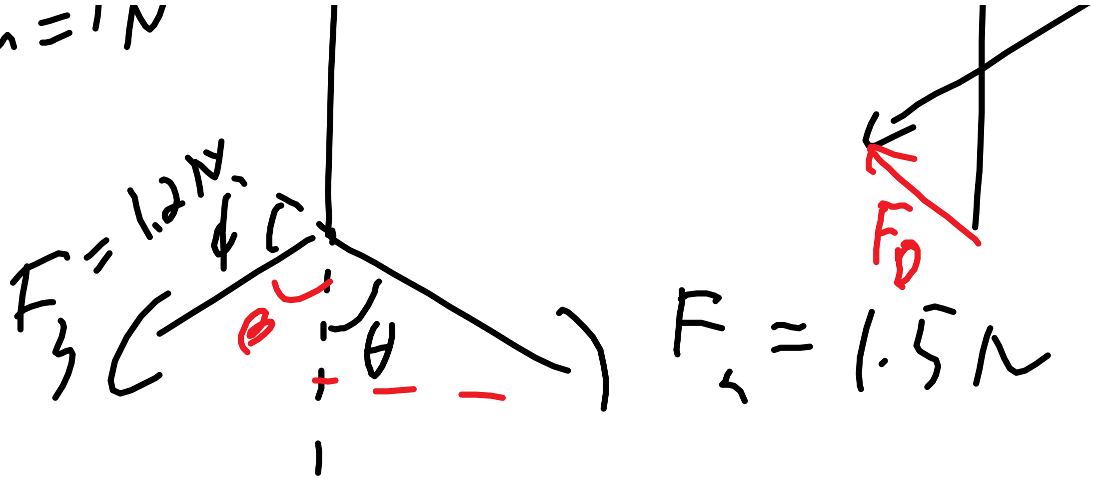
Scale

10cm = 1N

$F_1 = 1.7N$



10cm = 1N



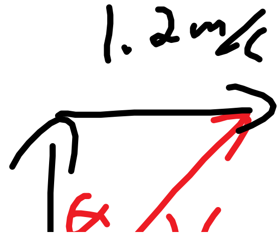
$$\cancel{F_{1x}}^{0} + F_2 \sin\theta + F_3 \sin\beta = \sum F_x$$

$$F_1 + F_2 \cos\theta + F_3 \cos\beta = \sum F_y$$

$$F_C = \sqrt{F_x^2 + F_y^2}$$

$$\%\,error = \frac{F_D - F_C}{F_C} \times 100\% =$$

a)

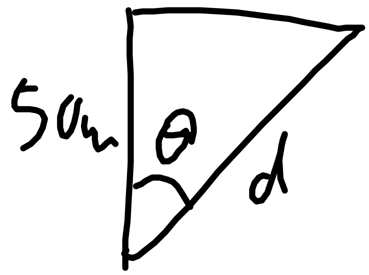


$\sqrt{\;\;^2 + (\;\;)^2} = 2.3m$...

$V_r = \sqrt{2^2 + 1.2^2} = 2.3\,m/s$

$\theta = \tan^{-1}\frac{1.2}{2} = 31°$

$t = \frac{d}{v}$



$\cos\theta = \frac{50}{d}$

$d = \frac{50}{\cos 31°}$

$t = \frac{58.3\,m}{2.33} = \boxed{25\,s}$

$d = 58.3$

or (Easy way)

$t = \frac{d_y}{v_y} = \frac{50\,m}{2.0\,m/s} = \boxed{25\,s}$

b)

$v = \sqrt{2^2 - 1.2^2} = 1.60$

$\boxed{1.6\,m/s}$

$t = \frac{50\,m}{1.60\,m/s} = \boxed{31\,s}$

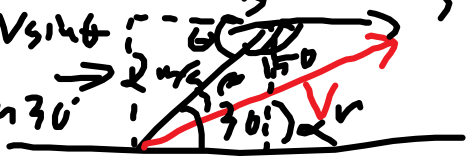
c) $V_x = V\cos\theta$
$= 2\cos 30°$

1.60 m/s

c) $V_x = V\cos\theta$
$= 2\cos 30°$
$= 1.7$ m/s

1.2 m/s

$V_y = V\sin\theta$
$= 2\sin 30°$
$= 1.0$ m/s



$$V^2 = 2^2 + 1.2^2 - 2(2)(1.2)(\cos 150)$$

$$V_r = 3.1 \text{ m/s}$$

$$V_r = \sqrt{V_y^2 + V_x^2}$$

$$= \sqrt{1^2 + (1.7+1.2)^2}$$

$$= \boxed{3.1 \text{ m/s}}$$

$$t = \frac{d_y}{V_y} = \frac{50\text{ m}}{1.0\text{ m/s}} = \boxed{50\text{ s}}$$

Block 1-3
Quiz, Lab, river, Giancoli

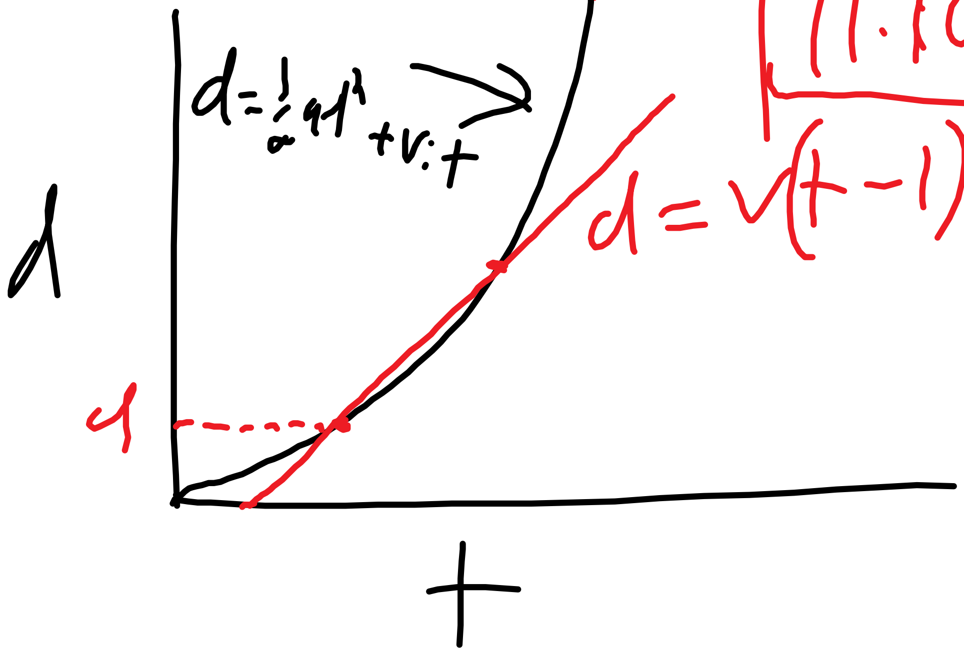
a,c round to lowest sfs, mxm = m^2
a) and c 3sfs 5.88 x 10^5
b) round to least precise decimal place

d)

1.2004 ms

$$\begin{array}{r} 0.00024 \\ 0.0601 \\ \hline 0.06025 \end{array} \qquad \begin{array}{r} 1.2004\ \text{ms} \\ 9.90\ \text{ms} \\ \hline 11.1004 \end{array}$$

$\boxed{11.10\ \text{ms}}$



a) $v_f = at + v_i = 7.0\,\text{m/s}$ or $6.0\,\text{m/s}$

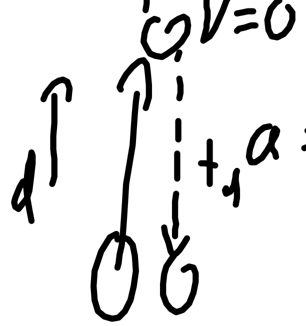
b) $d = \frac{1}{2}(v_i + v_f)t$ $\quad t = 3.3\,\text{s}$ or $3.6\,\text{s}$

c) $\frac{1}{2}at^2 + v_i t = v(t-1)$

$1.5t^2 - 9t + 10 = 0$ $\quad d = 4.7\,\text{m}$ or $35\,\text{m}$

$t^2 - 8t + 10 = 0$ $\quad d = 5.5\,m$ or $55\,m$?

d)



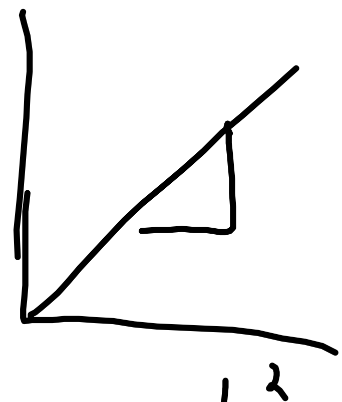
$a = -9.80\,m/s^2$

$d = \frac{1}{2} a t_d^2$

$t = 2 \times t_d = 1.5\,s$

$1.8\,s$

1/1



$1.0\,m/s^2$ or $4.0\,m/s^2$

3/3

$y = mx + b$

$$\boxed{y = 1.0\,m/s^2\, t^2}$$

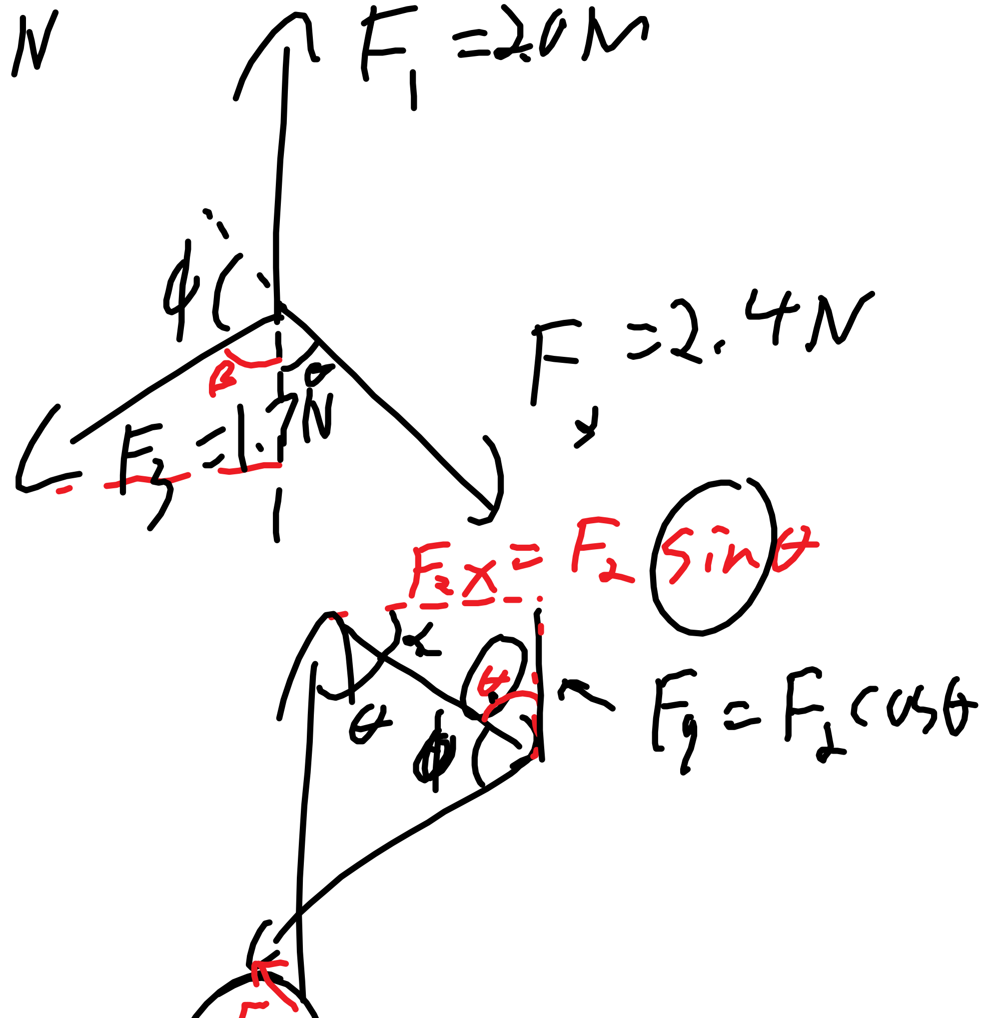
bonus $\quad d = \frac{1}{2} a t^2 \quad d = 2.0\,m/s^2$ or $8.0\,m/s^2$

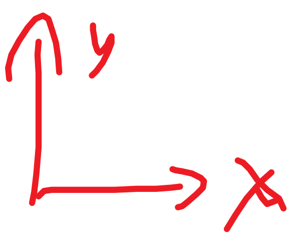
$a = g\sin\theta$

$a = g\sin\theta$

p35-37 labbook

10cm = 1N





F_R = ____ use ruler

$$\cancel{F_{1x}}^{\to 0} + F_{2}\sin\theta + \overset{(-)}{F_3}\sin\beta = \sum F_x$$

$$F \quad F_2\cos\theta + F_3\cos\beta = \sum F$$

$$F_1 - F_2\cos\theta + F_3\cos\beta = \Sigma F_y$$

$$F_{rc} = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$$

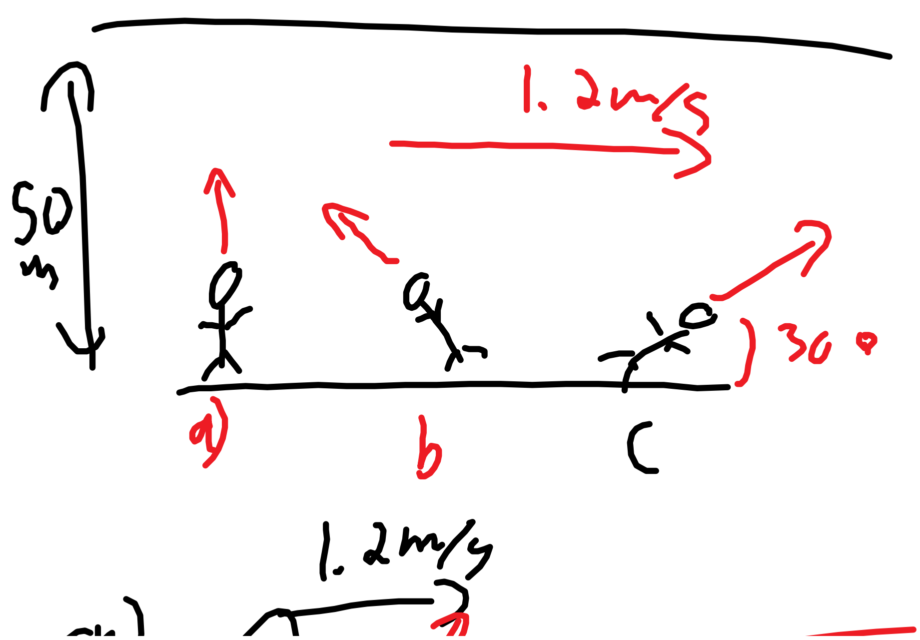
$$\%\,error = \frac{|F_{rc} - F_{rD}|}{F_{rc}} \times 100\%$$

eg. You swim at 2.00 m/s relative to the water in a river flowing at 1.20m/s. If you want to cross the river, how long does it take if you: - if the river is 50.0 m wide

a) point right across

b) point upstream so you end up directly across

c) point at 30.0º to the shore downstream

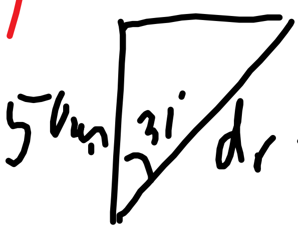


a)

$V_r = \sqrt{1.2^2 + 2^2} = 2.33 \text{ m/s} = \boxed{2.3 \text{ m/s}}$

$\theta = \tan^{-1} \frac{1.2}{2} = 31.0 = \boxed{31^\circ}$

hard way



$\cos 31 = \frac{50}{d_r}$

$d_r = \frac{50}{\cos 31^\circ} = 58.3 \text{ m}$

$t = \frac{d}{V} = \frac{58.3 \text{ m}}{2.33 \text{ m/s}} = \boxed{25 \text{ s}}$

easy way

$t = \frac{d_y}{V_y} = \frac{50 \text{ m}}{2.0 \text{ m/s}} = \boxed{25 \text{ s}}$

b)

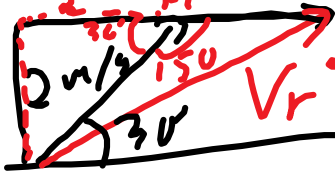
$V_r = \sqrt{2^2 - 1.2^2} = 1.60 \quad \boxed{1.6 \text{ m/s}}$

$t = \frac{d}{\ } = \frac{50 \text{ m}}{\ } = \boxed{31 \text{ s}}$

$$t = \frac{d}{V} = \frac{50\,m}{1.60\,m/s} = \boxed{31\,s}$$

c)

$V_x = V\cos\theta = 1.7$ 1.2 m/s



$V_y = V\sin\theta$

$2.0\,m/s \sin 30° = 1.0\,m/s$

$$V_r^2 = 2^2 + 1.2^2 - 2(2)1.2\cos 150°$$

$$V_r = 3.1\,m/s$$

$$V_r = \sqrt{V_y^2 + V_x^2}$$

$$= \sqrt{1.0\,m/s^2 + (1.7\,m/s + 1.2\,m/s)^2}$$

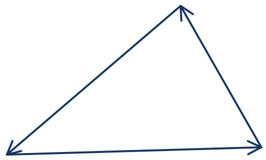
$$= \boxed{3.1\,m/s}$$

$$t = \frac{d_y}{V_y} = \frac{50\,m}{1.0\,m/s} = \boxed{50\,s}$$

Monday, October 05, 2015
8:38 AM

Block 2-1
Homework, Projectiles

p60
Q7



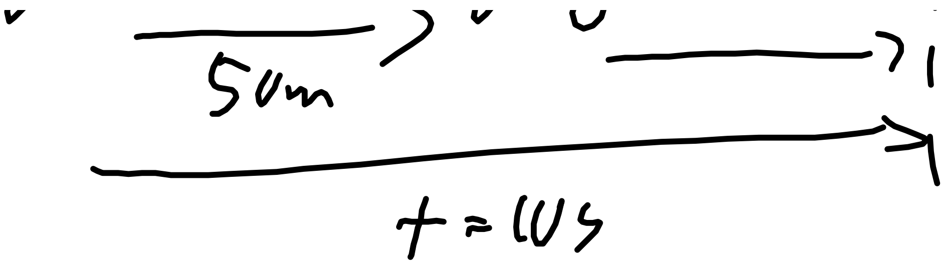
2 vectors - no
3 vectors - yes if they make a triangle

Q9 No, the vector is the hypotenuse of the triangle made by the components

Q11 the one pointing right across - the component of the velocity vector across the river is larger.

Q 31 $\vec{v_m} = 90\ km/h$ = $\vec{v_c} = 80\ km/h$

$d_c = vt$



$$d_m = \frac{1}{2}at^2 + v_i t$$

$$\frac{1}{2}at^2 + v_m t = v_c t + 50$$

Projectiles:
https://www.youtube.com/watch?v=abUBrQmI33Q
http://techtv.mit.edu/videos/735-monkey-and-a-gun

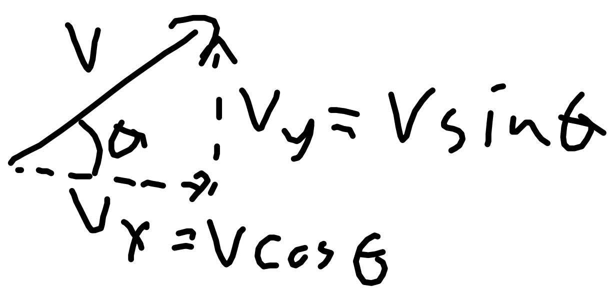
2 ideas:

1- If air resistance is negligible, then all masses (hammer or a paperclip) will fall at $9.80 m/s^2$ regardless of mass.

2- the rate an object falls is independent of the horizontal motion. so, a dropped bullet hits the ground at the same time as a sideways shot bullet.

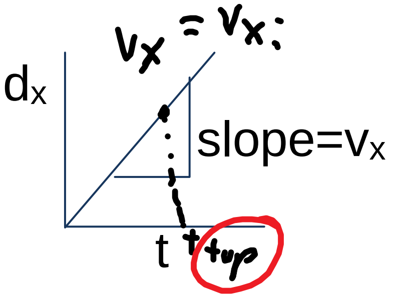
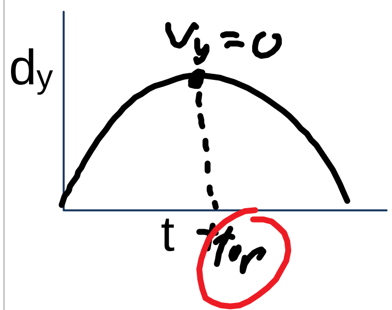
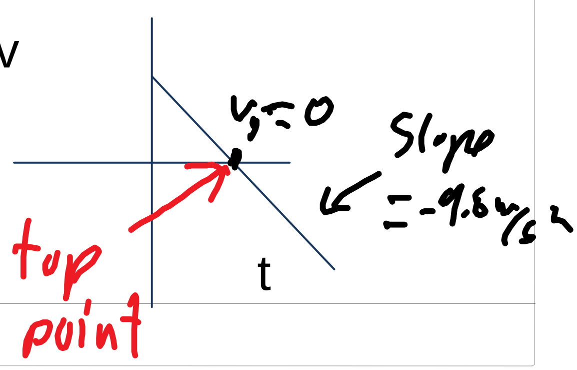
When solving projectile problems:

1. break the initial velocity into horizontal and vertical components v_x and v_y.
   $v_x = v\cos\theta$ and $v_y = v\sin\theta$
   where θ is the angle to the horizontal



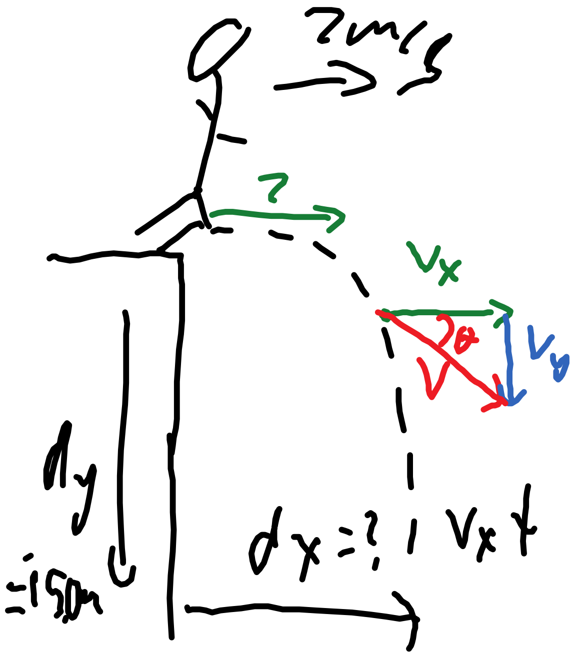
2. draw a diagram and write out the givens

3. find the equation relating your variables:
if air resistance is negligible,
what can you tell me about the x motion? (no forces) v_x is constant
the y motion, gravity causes the object to accelerate at $9.80 m/s^2$.

<table>
<tr><td>x</td><td>y</td></tr>
<tr><td>$d_x = v_x t$

</td><td>$d_y = 1/2gt^2 + v_{yi}t$

</td></tr>
<tr><td></td><td>$v_{yf} = v_{yi} + gt$

</td></tr>
<tr><td></td><td></td></tr>
</table>

eg. You run off a 15.0m high cliff and land in water. If your launch speed is 7.0m/s, when and where do you land? What is your velocity as you hit the water (include direction)?
a) you run off horizontally
b) you jump up at 37.0º (above the horizontal) at the edge of the cliff.

a) $V_x = 7.0\,m/s \quad V_y = 0$



$$d_y = \frac{1}{2} g t^2 + V_{y_i} t$$

$$-15m = \frac{1}{2}(-9.8)\,m/s^2\, t^2 + 0$$

*

$$t = \sqrt{\frac{30}{9.8}}$$

$$= 1.750\,s = \boxed{1.75\,s}$$

$$d_x = 7.0\,m/s \times 1.750\,s$$

$$= \boxed{12\,m}$$ from the base of the cliff

$$V_{y_f}^2 = V_{y_i}^2 + 2 g d_y$$

$$V_{y_f}^2 = 0 + 2(-9.80\,m/s^2)(-15.0\,m)$$

$$V_{y_f} = 17.15\,m/s$$

$$V = \sqrt{V_{y_f}^2 + V_x^2} = \sqrt{17.15^2 + 7^2}$$

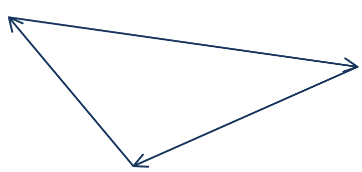
$$= \sqrt{} = 18.52 \text{ m/s}$$

$$= 1\cancel{8.5 \text{ m/s}}\ \boxed{9 \text{ m/s}}$$

$$\theta = \tan^{-1} \frac{17.15}{7} = \boxed{68^\circ \text{ below horizontal}}$$

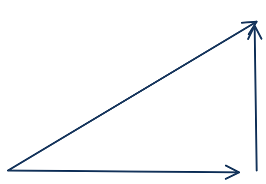
Block 1-2
Homework then Projectiles Intro

p60
Q7



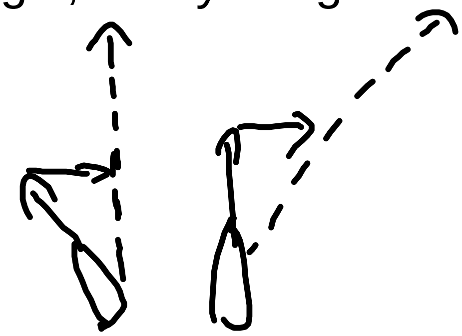
2 vectors: no
3 vectors only if they make a triangle

Q9



No, the resultant is the hypotenuse of the triangle, always larger than the components

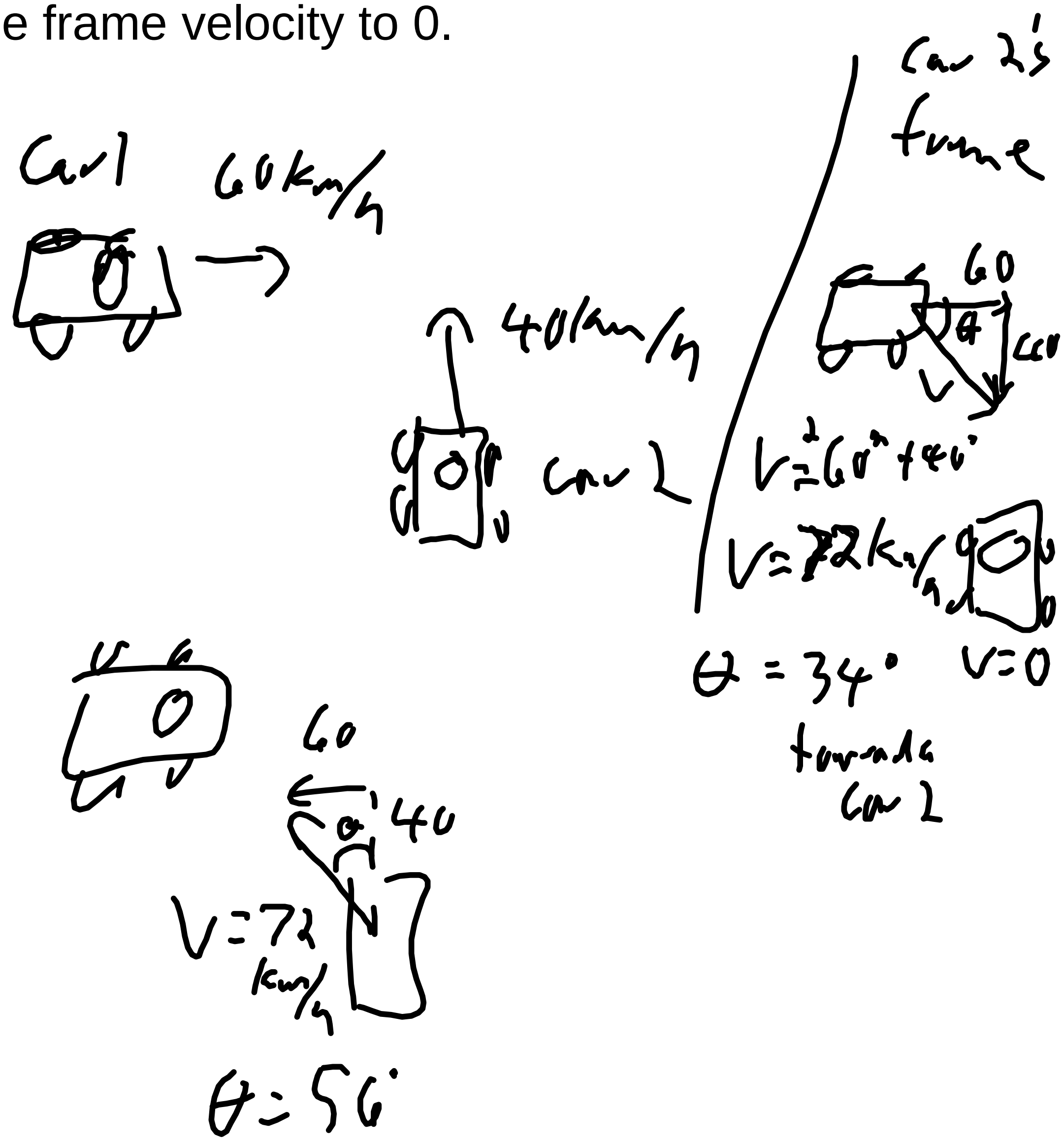
Q11



slower

faster because larger y component

p62 Q29
switch frames of reference, you add velocities to set the frame velocity to 0.



it is moving at 72 km/h, 56º from the original direction towards car 1.

Projectiles:

2 demos -

1- drop a hammer, feather and paperclip

2- drop 2 pens, one horizontal one vertical.

1. the feather falls slower because of air resistance. the hammer and the paperclip fall at the same rate, $9.80 m/s^2$, even though they have a very different mass.

Big Idea: if air resistance is negligible, objects fall at $9.80 m/s^2$ near Earth.

2. the 2 pens hit the table at the same time, independent of the sideways velocity.

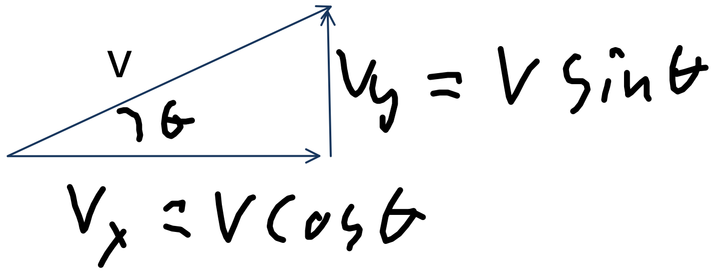
   https://www.youtube.com/watch?v=abUBrQmI33Q

   http://techtv.mit.edu/videos/735-monkey-and-a-gun

   Big Idea: objects fall at $9.80 m/s^2$ regardless of the sideways motion (ignoring air resistance).

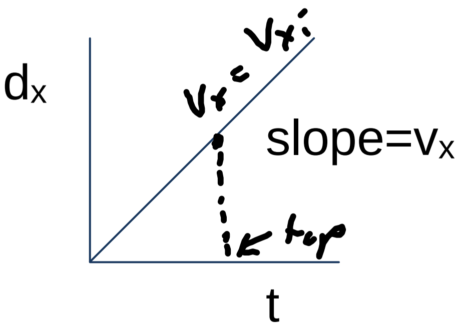
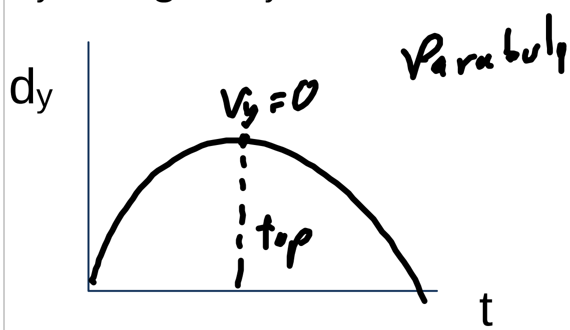
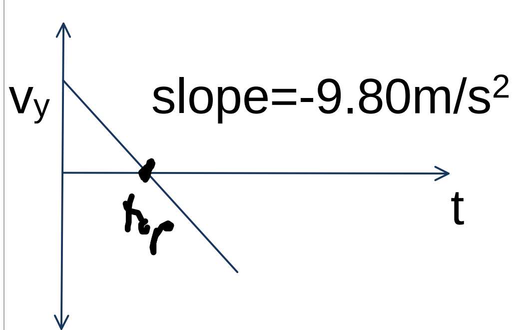
   Projectile problems:

1. determine the horizontal, x, and vertical, y, components of the velocity.



2. Draw a diagram with knowns and unknowns.

3. use your equations:

x	y
there is no force in the x direction, so v_x is constant $d_x = v_x t$ 	gravity causes the object to accelerate at $-9.80 m/s^2$ v_y is constantly changing $d_y = 1/2gt^2 + v_{yi}t$ 
	$v_{yf} = v_{yi} + gt$ 

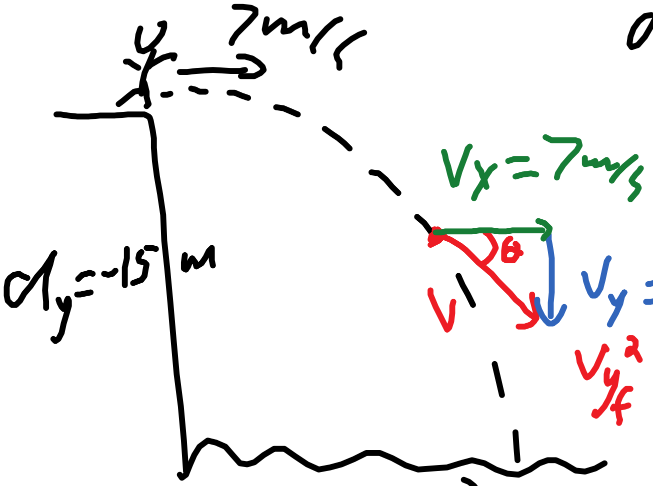
eg. You run off a 15.0m high cliff and land in water. If your launch speed is 7.00 m/s, when and where do you land? What is your velocity

as you hit the water? (include direction)

a) you run off horizontally

b) you jump up at 37.0º (above the horizontal) at the edge of the cliff.

$d_y = \frac{1}{2} g t^2 + \cancel{v_{y_i} t} \rightarrow 0$



$t = \sqrt{\frac{2 d_y}{g}} = \boxed{1.75 s}$

$v_y = v_{y_i} + g t$

$v_{y_f}^2 = v_{y_i}^2 + 2 g d$

$d_x = \vec{v_x} t = 7.00 m/s (1.750 s) = \boxed{12.3 m}$

$v_{y_f}^2 = 0 + 2(-9.80 m/s^2)(-15.0 m)$

$v_{y_f} = 17.1 m/s$ *

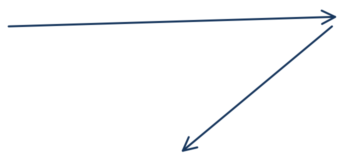
$V = \sqrt{v_x^2 + v_y^2} = \sqrt{7^2 + 17.1^2}$

$\boxed{V = 18.5 m/s}$ $\theta = \tan^{-1} \frac{v_y}{v_x}$

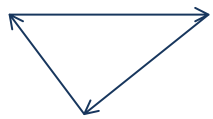
$\theta = \tan^{-1} \frac{17.1}{7} = \boxed{67.7^\circ \text{ below horizontal}}$

Block 1-2
Homework then Projectiles Intro

p60
Q7



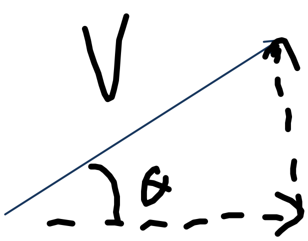
2 vectors, no way



SOHCAHTOA

3 vectors if they make a triangle

Q9

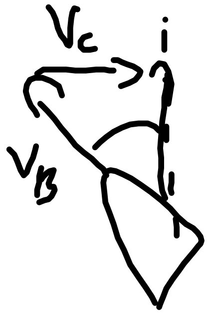


No

$V_y = V\sin\theta$

$V_x = v\cos\theta$

Q11

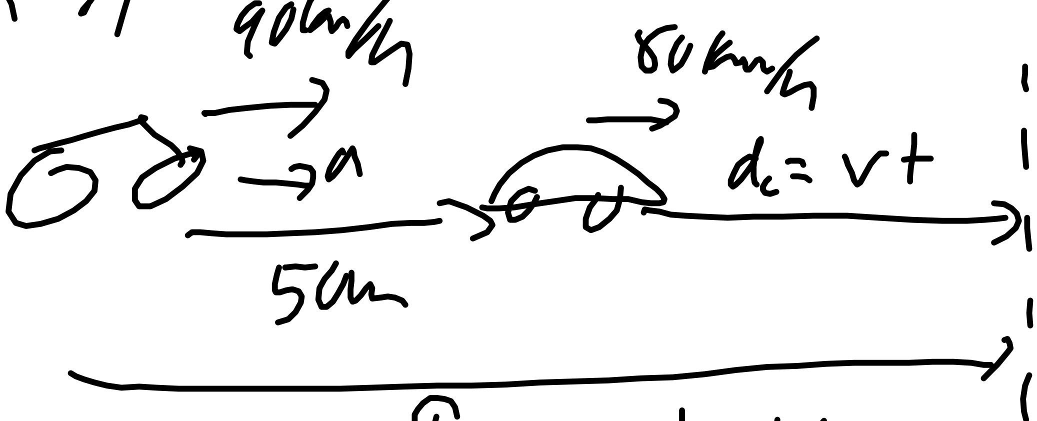


$t = \frac{d}{V_y}$

* faster
y component >

P62

Q3/



$t = 10s$

$d_m = \frac{1}{2}at^2 + v_i t$

$d_m = d_c + 50m$

$\frac{1}{2}at^2 + V_m t = V_c t + 50m$

$\underline{(V_m - V_c)}\, t$

Projectiles

define: object moving through the air without propulsion or lift.

Demos: 1. drop a hammer, feather, paperclip
2. drop 2 pens, one straight down, the other thrown sideways - which will hit the ground first?

1. feather drops slower because of air resistance
   the hammer and the paperclip drop at the same rate because air resistance is negligible
   $a=g=9.80 m/s^2$ near Earth

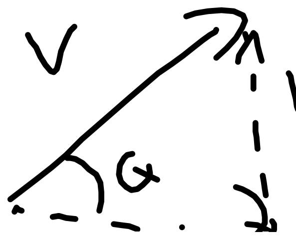
2. The pens land at the same time regardless of the sideways velocity.

   the horizontal and vertical motions can be considered independent.

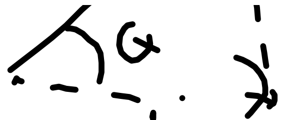
   Assuming air resistance is negligible:

How should we answer projectile problems?

1. get the horizontal, x, and vertical, y, components of the velocity.



$V_y = V \sin\theta$

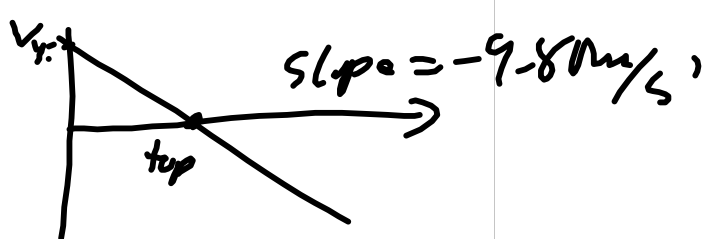


$V_x = V\cos\theta$

2. Draw a diagram with givens and unknowns

3. Equations relating givens and unknowns
   no x forces, so v_x is constant
   gravity pulls in the y direction, so $a_y=g=-9.80m/s^2$

x	y

x	y
$d_x=v_xt$ d_x slope=v_x t	$d_y=1/2gt^2 + v_{yi}t$ d_y t
	$v_{yf} = v_{yi}+gt$ v_y  t

eg. You run off a 15.0m high cliff and land in water. If your launch speed is 7.00m/s, when and where do you land? What is your velocity

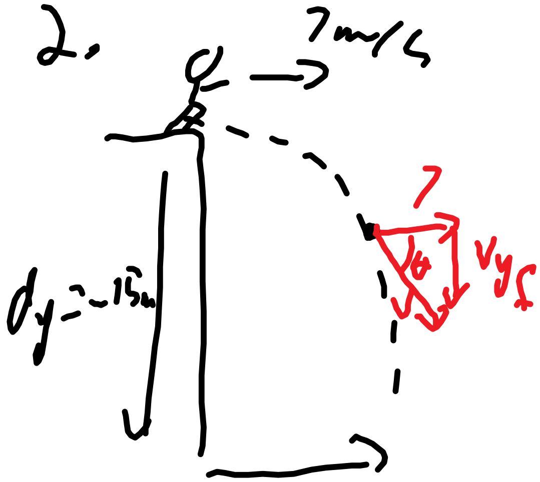
as you hit the water? (include direction)

a) you run off horizontally

b) you jump up at 37.0º (above the horizontal) at the edge of the cliff (speed is still 7.00m/s).

1. $\underline{V_x = 7.00\,m/s}$ $\quad \underline{V_{y_i} = 0}$ *

2.



$d_x = v_x t$

$$d_y = \frac{1}{2}at^2 + \cancel{v_{y_i} t} \quad 0$$

$$t = \sqrt{\frac{2d_y}{a}} = \sqrt{\frac{2 \cdot -15}{-9.8}}$$

$$= \boxed{1.75\,s}$$

$$d_x = 7.0\,m/s\,(1.75\,s) = \boxed{12.2\,m}$$

from base of clif

$$V_f^2 = V_{y_i}^2 + 2gd_y$$

$$V_{y_f} = \sqrt{2(-9.8)(-15)} = 17.1\,m/s$$

$$V = \sqrt{V_x^2 + V_y^2} = \sqrt{7^2 + 17.1^2}$$

$$\boxed{V = 18.5\,m/s}$$

$$\theta = \tan^{-1}\frac{17.1}{7} = \boxed{67.7^\circ \text{ *below horizontal}}$$

Friday, October 09, 2015
9:00 AM

Block 1-1
using a word processing document for the report, then save as pdf and e-mail to aklaassen@vsb.bc.ca
name and block in subject line
1 video per group - no data
1 lab report per person with data and 3 graphs
x-t, y-t and vy-t graphs

Projectile Lab

Name

Partners name:

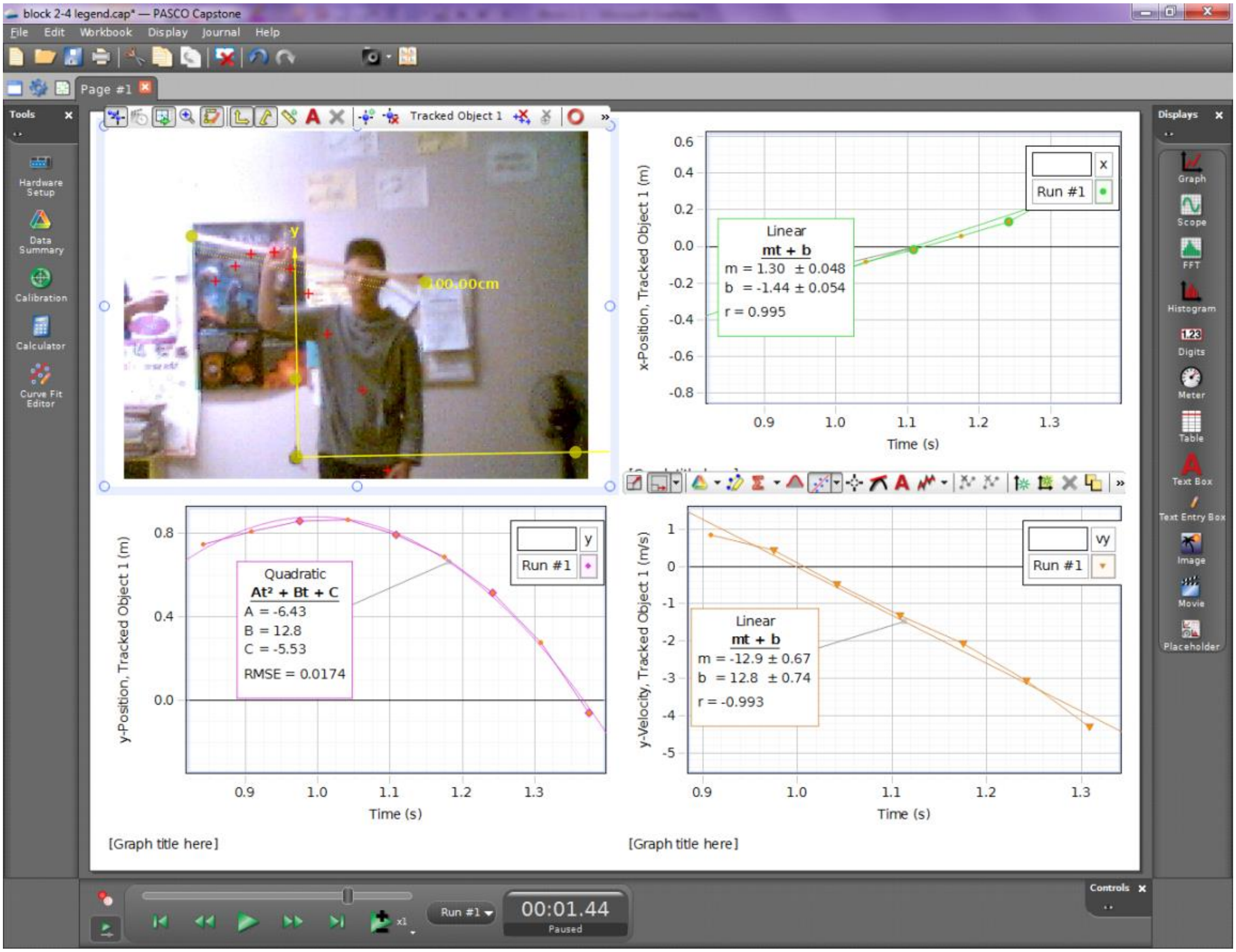
block

Purpose

Hypothesis

Procedure

Observations:



Analysis: d

Equation of each graph

$d_x = 1.30 m/s \; t - 1.44 m$

$d_y = 6.43 m/s^2 \; t^2 + 12.8 \; m/s \; t - 5.5 m$

$v_y = -12.9 m/s^2 \; t - 12.8 \; m/s$

%error = |exp-theo|/theo x 100%

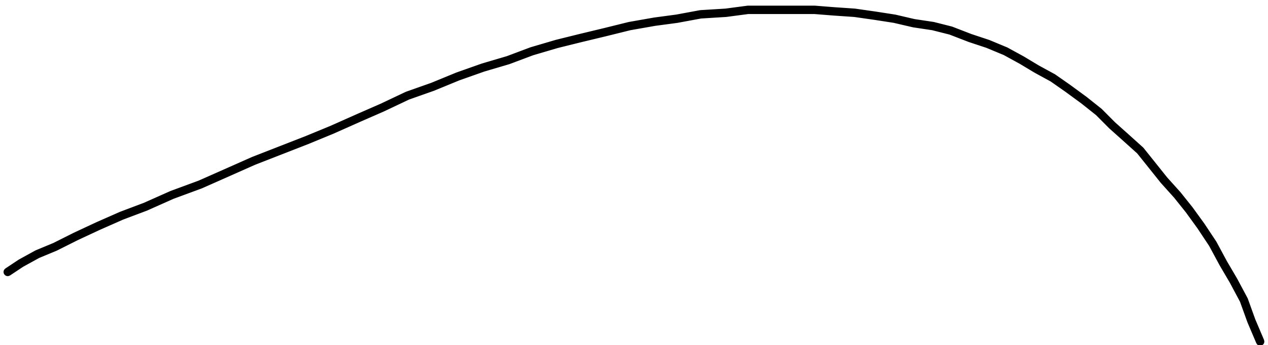
Eg. $|-12.9 m/s^2 - -9.80 m/s^2|/9.80 \times 100\%$

=

Conclusion- does each graph match hypothesis?

Conclusion- does each graph match hypothesis?

Sources of uncertainty- estimate of the quantity – evidence in the data



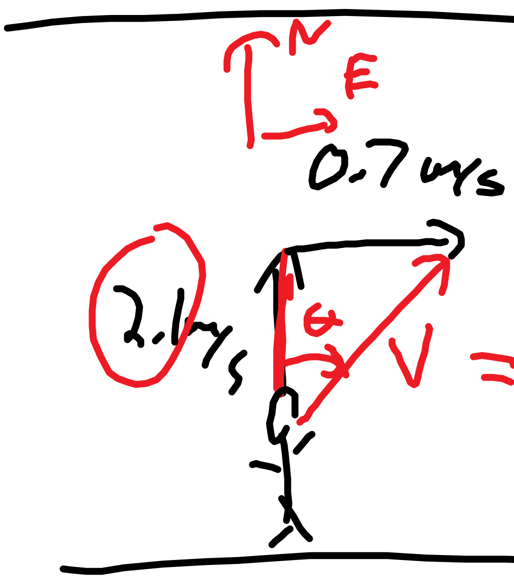
Wednesday, October 14, 2015
8:41 AM

Pop Quiz Projectiles

Friday, October 16, 2015
8:39 AM

Review for test next class (Oct 20th)
go over vector quiz, homework, projectile quiz

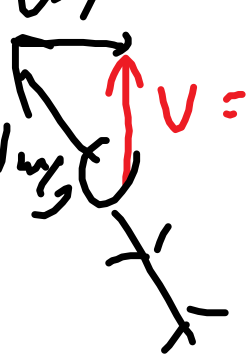
Block 1-1



a) $V = \sqrt{0.7^2 + 2.1^2} = \boxed{2.21\,m/s}$

$\Theta = \tan^{-1}\frac{0.7}{2.1} = \boxed{18.4^\circ \text{ E of N}}$

b)



$V = \sqrt{2.1^2 - 0.7^2} = 1.9\,m/s$

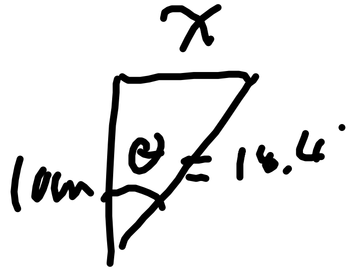
$a^2 + b^2 = c^2$

$b^2 = c^2 - a^2$

c) Sandy $\frac{100m}{1.9\,m/s}$ Michael $= \frac{100m}{V_y} = \frac{100}{2.1}$

1.9 m/s … V_y 2.1

d)

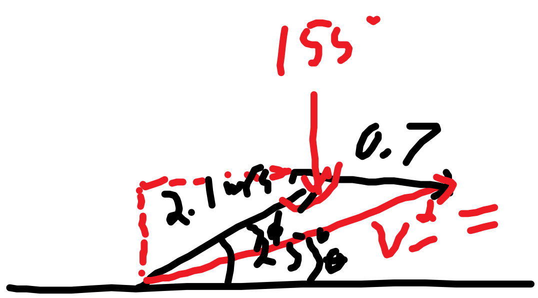


$$\tan\theta = \frac{x}{100}$$

$$x = 100 \tan 18.4°$$

$$d_x = v_x t = 0.700\ \text{m/s}\ \ t_{channel}$$

e)



$$v^2 = 2.1^2 + 0.7^2 - 2(2.1)(0.7)\cos 155°$$

2.75 m/s

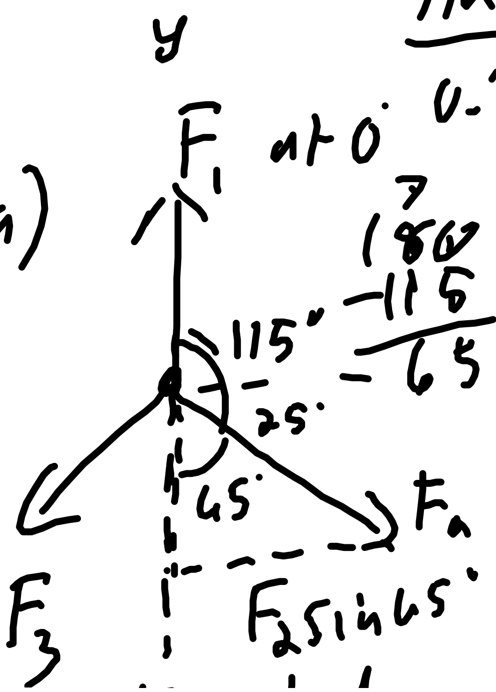
$$\frac{\sin\phi}{0.7} = \frac{\sin 155}{2.75} \qquad \phi =$$

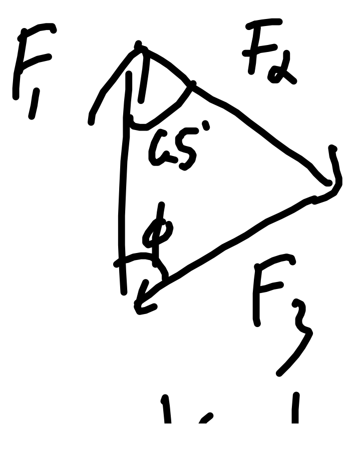
$$\theta = 25 - \phi \approx 18°$$

N of E

2 a) F_1 at 0°

$$\begin{array}{r} 180 \\ -115 \\ \hline 65 \end{array}$$





F_3 ; $F_2 \sin 65$

Free body

Vector Addition

b) $F_3^2 = F_1^2 + F_2^2 - 2F_1F_2\cos 65°$

$$\frac{\sin\phi}{F_2} = \frac{\sin 65°}{F_3}$$

$F_{1x} = 0$

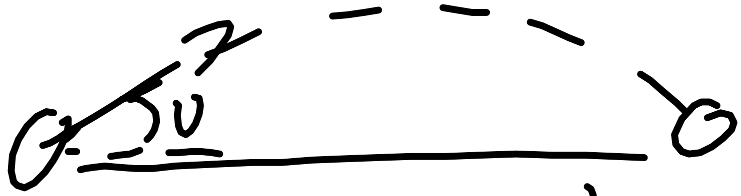
$F_{1y} = F_1 = 2.00N$

$F_{2x} = F_2 \sin 65° =$

$F_{2y} = -F_2 \cos 65°$

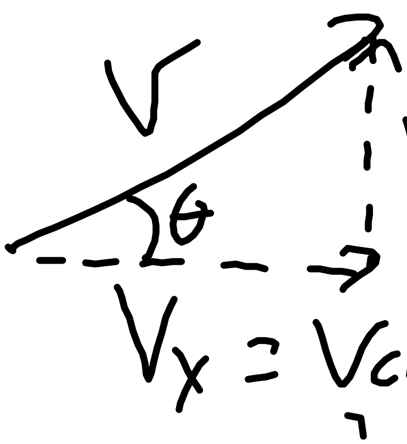
$F_{3x} = -F_{2x}$

$F_{3y} = F_1 - |F_{2y}|$



$$d_x = \frac{V^2 \sin 2\theta}{g}$$ only if $d_y = 0$

Projectile quiz



$V_y = V\sin\theta = 5\,m/s\,\sin 35° = \boxed{2.87\,m/s}$

$V_x = V\cos\theta = 5\cos 35° = \boxed{4.10\,m/s}$

V_x is constant $a_y = -9.80\,m/s^2$

b) $d_y = ?$ $a = -9.80\,m/s^2$ $\boxed{V_{yi} = 2.87\,m/s}$

$V_{yf} = 0$

$$V_{yf}^2 = V_{yi}^2 + 2 g d_y$$

$$V_{yf}^2 = V_{yi}^2 + 2g\,d_y$$

$$0 = 2.868^2 + 2(-9.8)(d_y)$$

$$\boxed{d_y = 0.420\text{m}}$$

c) $t = \dfrac{V_{yf} - V_{yi}}{g} = \dfrac{0 - 2.868}{-9.80}$

$$= \boxed{0.293\text{s}}$$

d) $V_{yf} = V_{yi} + gt \qquad V_{xf} = V_{xi} = 4.10\text{m/s}$

$$V = \sqrt{V_x^2 + V_y^2}$$

$$V_{yf} = -9.8(0.5) + 2.868 = -2.032$$

$$V = \sqrt{4.10^2 + 2.032^2} = 4.57\text{m/s}$$

$$\theta = \tan^{-1} \frac{V_y}{V_x} = \tan^{-1} \frac{2.033}{4.10}$$

$$= 26.4^\circ$$

$$\boxed{4.57\ \text{m/s}\ 26.4^\circ \text{ below horizontal}}$$

e) $d_x = V_x t = 4.0955\ \text{m/s} \times 2 \times 0.293\ \text{s}$

↑ up + down

$$= \boxed{2.40\ \text{m}}$$

f) $d_x = V_x t \qquad d_y = \frac{1}{2} g t^2 + V_{yi} t$

$t = \frac{d_x}{V_x} \qquad \underline{\underline{0}} = \frac{1}{2} g t + V_{yi}$

$$0 = \frac{1}{2} g \left(\frac{d_x}{V_x} \right) + V_{yi}$$

$$\frac{g d_x}{2V_x} = -V_{yi}$$

$v\sin\theta$ $\quad$ $v\cos\theta$

$$d_x = -\frac{2V_{yi}V_x}{g}$$

$$d_x = -\frac{2V^2\sin\theta\cos\theta}{g}$$

$$10 = -\frac{2V^2\sin 35^\circ\cos 35^\circ}{-9.8}$$

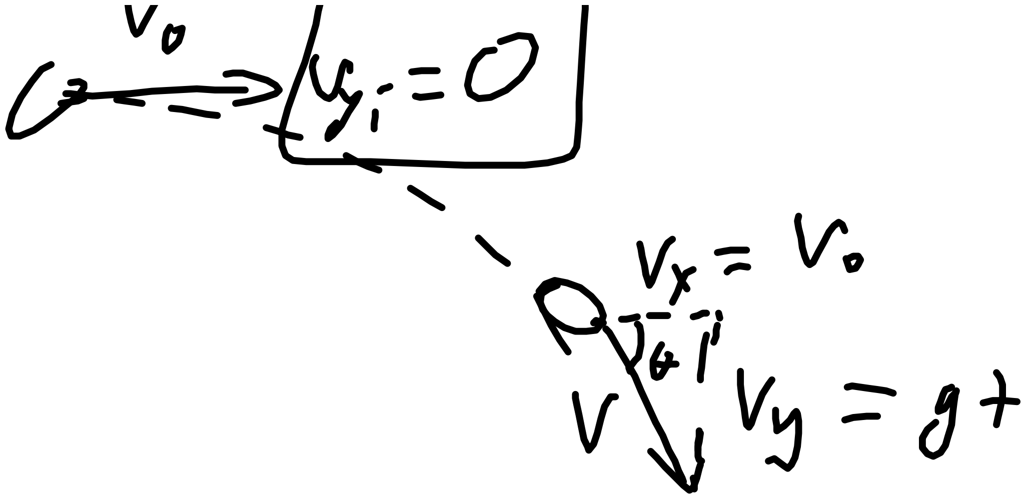
$$\boxed{V = 10.2\,m/s}$$

Since $2\sin\theta\cos\theta = \sin 2\theta$

$$d_x = -\frac{V^2\sin 2\theta}{g} \Leftarrow Q45$$

Q49

p64



$$\tan\theta = \frac{v_y}{v_x} = \frac{gt}{v_0}$$

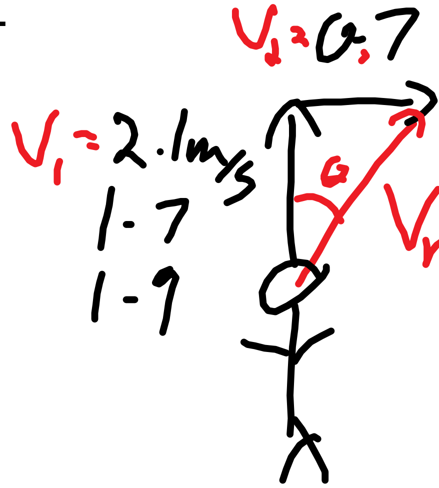
$$\boxed{\theta = \tan^{-1}\frac{gt}{v_0}}$$

Review for test next class (Oct 20th)
go over vector quiz, homework, projectile quiz

Block 1-2
Vectors quiz
1

Vectors quiz

1

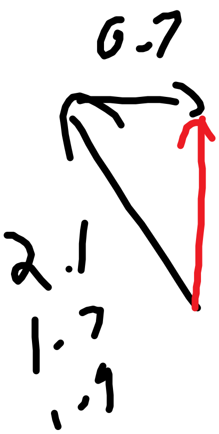


$$V_r = \sqrt{V_1^2 + V_2^2} = 2.21 \text{ m/s}$$

$$\theta = \tan^{-1}\frac{V_2}{V_1} \quad \text{E of N}$$

18.4° E of N

b)



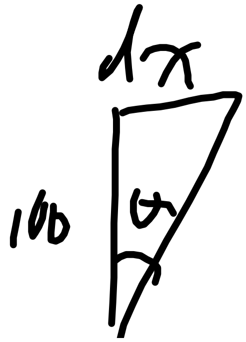
$$V = \sqrt{V_1^2 - V_2^2} \quad \text{North}$$

$= 1.9$ m/s

c) $\cancel{d_y = V_y}$ $\quad t = \frac{d_y}{V_y}$

$$t_s = \frac{100\text{m}}{V} \qquad t_n = \frac{100\text{m}}{V_1} = \begin{matrix} 2.1 \\ 1.9 \\ 1.7 \end{matrix}$$

d)

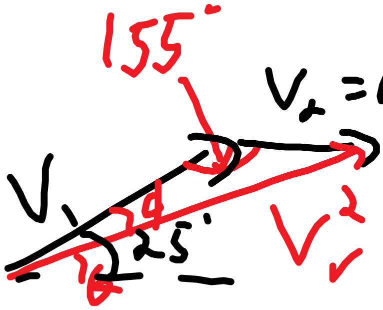


$$d_x = 100 \sin\theta$$

or $d_x = V_x t = 0.7(t_n)$

or $d_x = v_x t = 0.7\, t_M$

e)

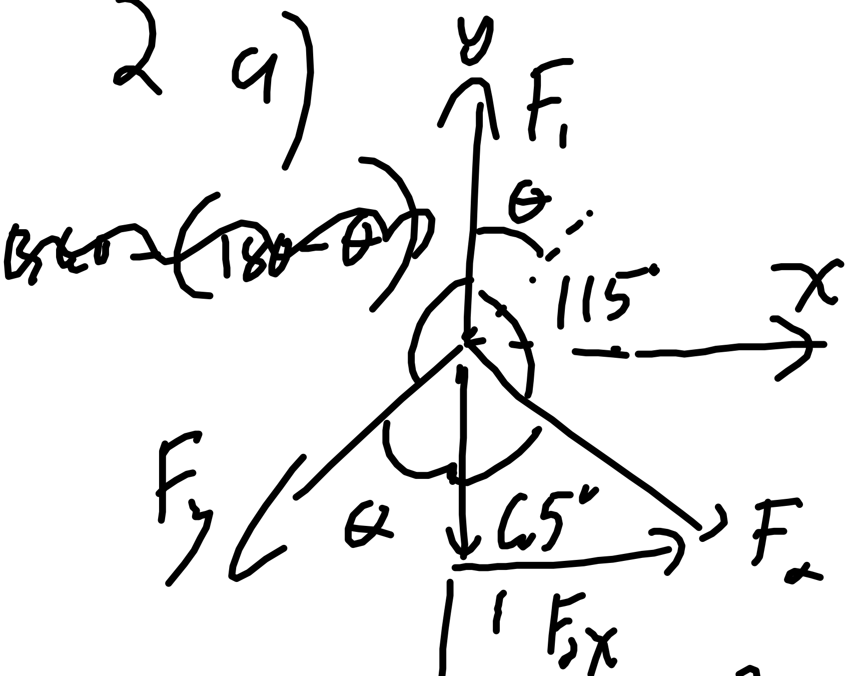


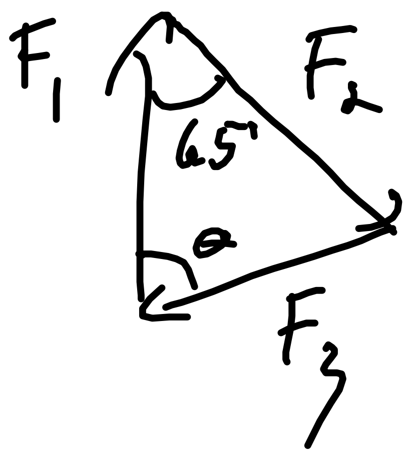
$$V_r^2 = V_1^2 + V_a^2 - 2V_1V_a\cos 155°$$

$$\frac{\sin\phi}{V_a} = \frac{\sin 155°}{V_r}$$

$$\theta = 25 - \phi$$
$$= 18°$$

2 a)





b) $F_3^2 = F_1^2 + F_2^2 - 2F_1F_2\cos 65°$

$\sin 65 = \sin\theta$

$\overline{F_3}$ $\overline{F_2}$

c)

$$F_{1x} = 0$$

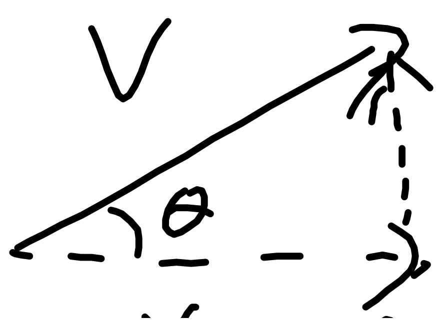
$$F_{1y} = F_1$$

$$F_{2x} = F_2 \sin 45^\circ$$

$$F_{2y} = -F_2 \cos 45^\circ$$

$$F_{3x} = -F_{2x}$$

$$F_{3y} = F_1 - |F_{2y}|$$



2.11309

$$V_y = V \sin \alpha$$

$$= 5 \sin 25 = \boxed{2.11 \, m/s}$$

$V_x = V\cos\theta = 5\cos 25 = \boxed{4.53\,m/s}$

V_x is constant $a_y = -9.80\,m/s^2$

b) $V_{yf} = 0$ $d_y = ?$ $g = -9.80\,m/s^2$

$\boxed{\cancel{V_{yi} = 2.81\,m/s}}$

$V_f^2 = V_i^2 + 2ad$

$0 = (2.81)^2 + 2(-9.8)\,d$

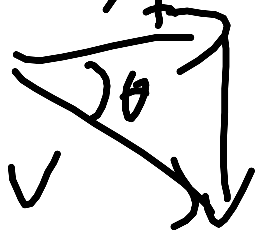
$\boxed{\cancel{d = 0.2182\,m}}$

$\boxed{d = 0.228\,m}$

c) $t = \frac{V_f - V_i}{g} = \frac{0 - 2.11}{-9.8} = \boxed{0.216\,s}$

d)

$v_{x_f} = v_{x_i} = 4.53\,m/s$



$v_{y_f} = gt + v_{y_i}$

$= -9.8(0.5) + 2.11$

$= -2.786$

$v = \sqrt{v_x^2 + v_y^2} = \sqrt{2.786^2 + 4.53^2}$

$\boxed{v = 5.32\,m/s}$

$\theta = \tan^{-1}\dfrac{2.786}{4.53}$ $\boxed{= 31.6^\circ \text{ below horizontal}}$

e) $\underline{d_x = v_x t} = 4.53\,m/s \times 0.216\,s \times 2$

$$= \boxed{1.95\,m}$$

up + down

f) $d_x = V_x t$ $\qquad$ $d_y = \frac{1}{2} g t^2 + V_{yi} t$

$t = \frac{d_x}{V_x}$ $\qquad$ $\frac{0}{t} = \frac{\frac{1}{2} g t^2}{t} + \frac{V_{yi} t}{t}$

$0 = \frac{1}{2} g t + V_{yi}$

$V_{yi} = -\frac{g t}{2}$ $\qquad$ $\frac{-g\, d_x}{2\, V_x} = V_{yi}$

$2 V_x V_{yi} = -g d_x$

$2 V \cos\theta\, V \sin\theta = -g d_x$

$2 v^2 \sin\theta \cos\theta = -g d_x$

$2 v^2 \sin 25 \cos 25 = -(-9.8)\, 10$

$\boxed{V = 11.3\,m/s}$

$$\boxed{v = 11.3\,m/s}$$

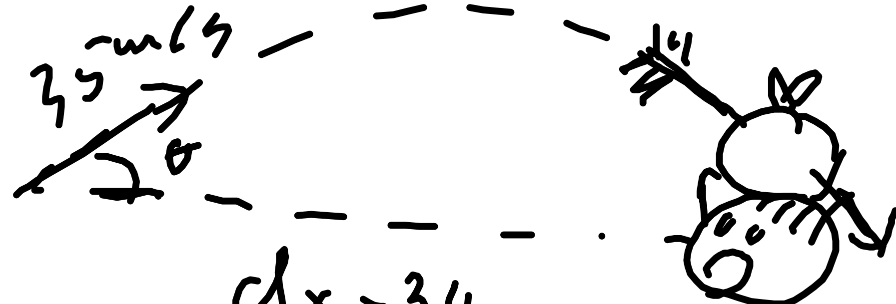
$$d_x = -\frac{2v^2 \sin\theta \cos\theta}{g}$$

range

$$d_x = -\frac{v^2 \sin 2\theta}{g}$$

only if $d_y = 0$

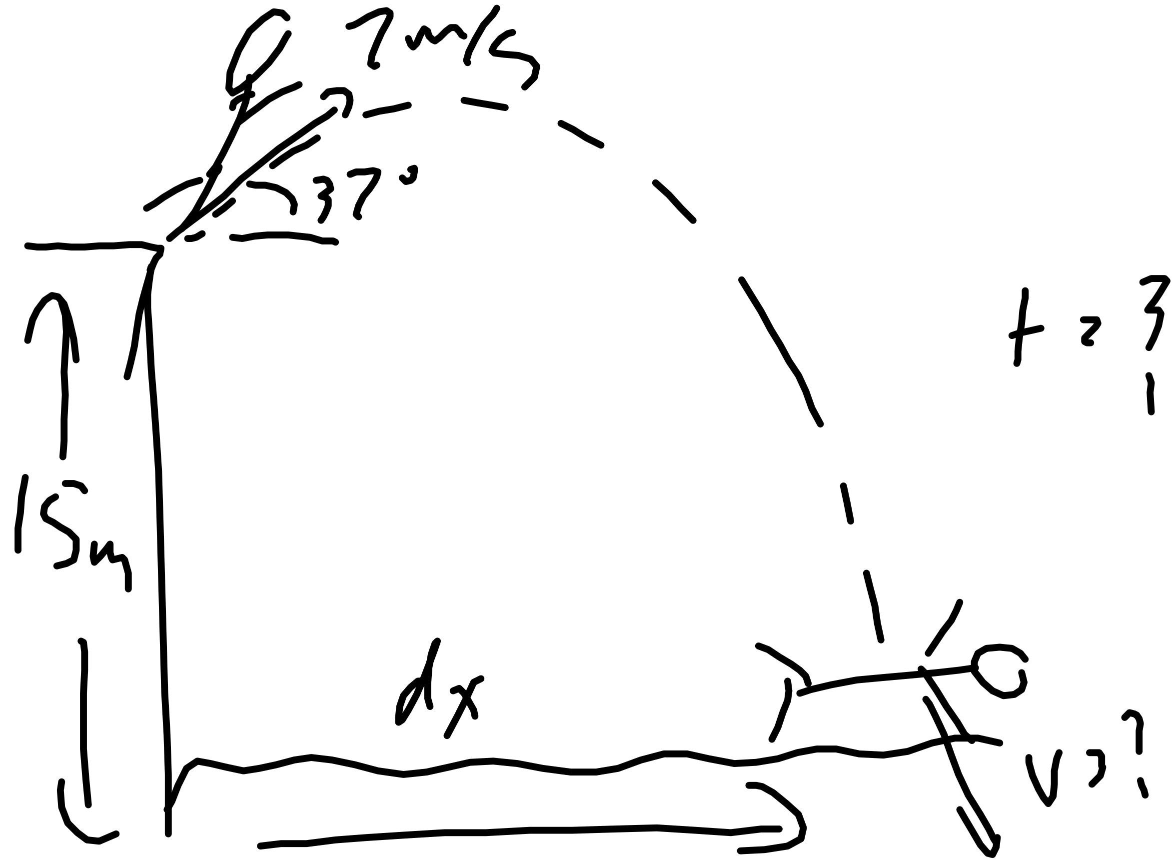
Q45



$d_x = 30m$

$$30 = -\frac{(35)^2 \sin 2\theta}{-9.8}$$

$$\boxed{\theta = 6.9^\circ}$$



$$d_y = \frac{1}{2} g t^2 + V_{yi} t$$

$$V_{yi} = V \sin\theta$$
$$= 7 \sin 37°$$
$$= 4.2127 \text{ m/s}$$

$$-15m = \frac{1}{2}(-9.8)t^2 + 4.2127t$$

$$t = \frac{-4.2127 \pm \sqrt{4.2127^2 - 4(-4.9)15}}{2(-4.9)}$$

$$t = \frac{-4.2127 \pm 17.654}{-9.8}$$

a) $t = 2.23154s = \boxed{2.23s}$

b) $d_x = v_x t = 7\cos 37 \times 2.23154s$
$= 12.475 = \boxed{12.5m}$

c) $v_x = 7\cos 37 = 5.590 m/s$

$v_{y_f}^2 = v_{y_i}^2 + 2ad_y$

$v_{y_f} = \sqrt{4.214^2 + 2(-9.8)(-15)}$

$= 17.656 m/s$

$v = \sqrt{v_x^2 + v_y^2} = \sqrt{5.590^2 + 17.65^2}$

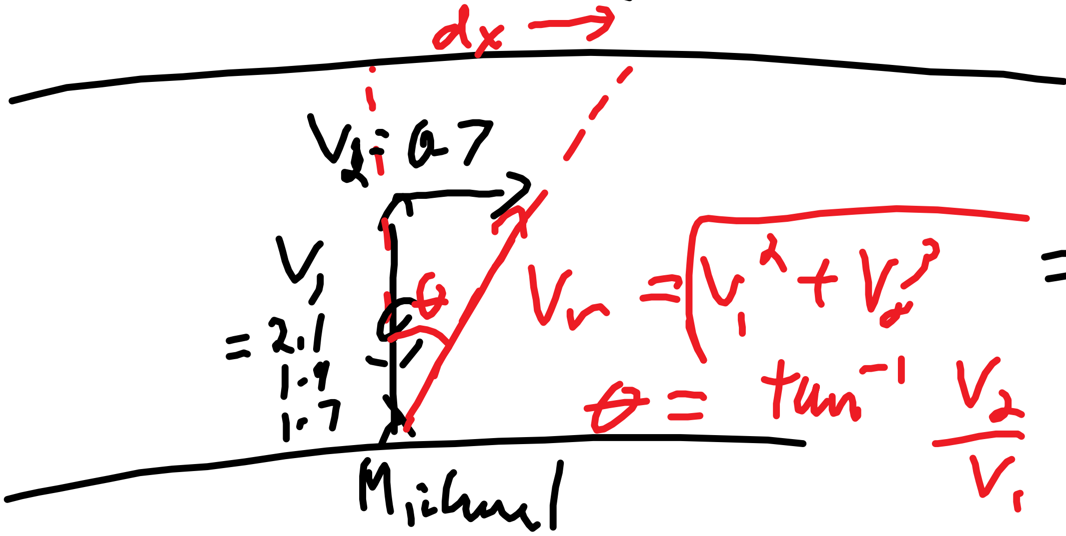
$\boxed{v = 18.5 m/s}$

$$\boxed{V = 18.5\ m/s}$$

$$\theta = \tan^{-1}\frac{V_y}{V_x} = \frac{17.66}{5.576} = \boxed{72.4^\circ \text{ below horizontal}}$$

Review for test next class (Oct 20th)
go over vector quiz, homework, projectile quiz

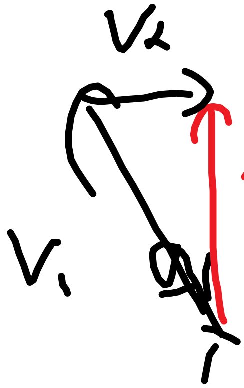
Vectors Quiz



$$V_r = \sqrt{V_1^2 + V_2^2} = 2.2\ m/s$$

$$\theta = \tan^{-1}\frac{V_2}{V_1} = 18^\circ \text{ E of N}$$

b)

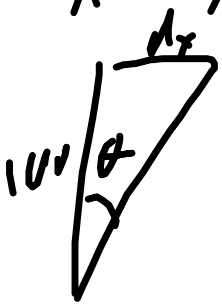


$$V = \sqrt{V_1^{\,2} - V_2^{\,2}}$$

c) $t = \dfrac{d}{V} = \dfrac{d_y}{V_y}$ $\quad t_m = \dfrac{100\,m}{V_1}$ $= 2.1,\ 1.9,\ 1.7$

$$t_s = \frac{100\,m}{V}$$

d) $d_x = ?$



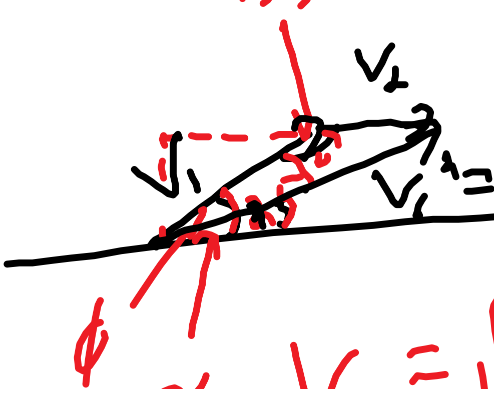
$d_x = 100 \tan\theta$

$d_x = V_x t = V_2\, t_M$

V_2: 0.7 m/s

e)

155°



$$V_r^{\,2} = V_1^{\,2} + V_2^{\,2} - 2V_1V_2\cos 155^\circ$$

ϕ

$V_r = \sqrt{(V_1\sin\phi)^2 + (V_1\cos\phi + V_2)^2}$

ϕ ' ' α $V_r = \sqrt{(V_1 \sin\theta)^2 + (V_1 \cos\theta + V_2)^2}$

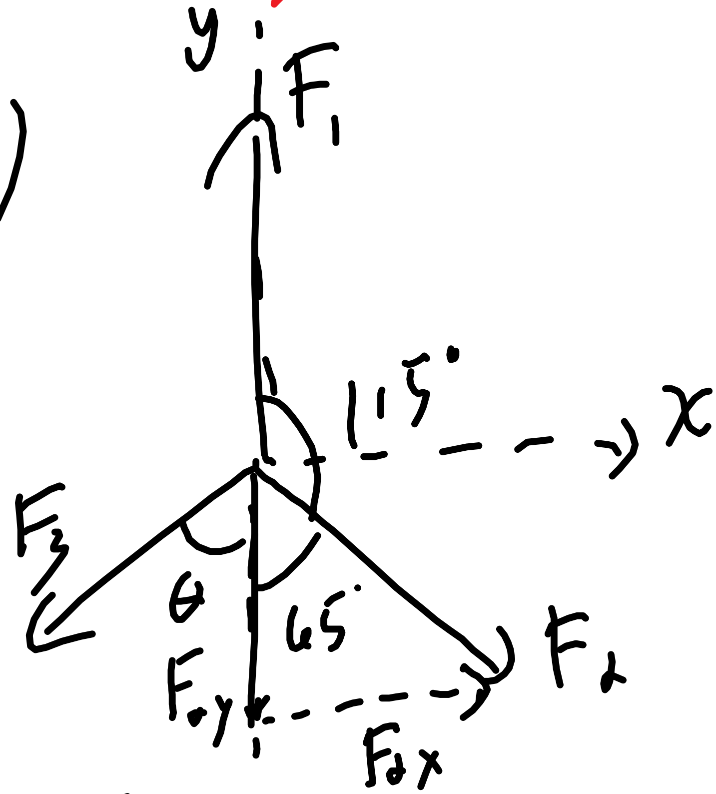
$$\frac{\sin\phi}{V_a} = \frac{\sin(155}{V_r}$$

$\alpha = 25° - \phi$

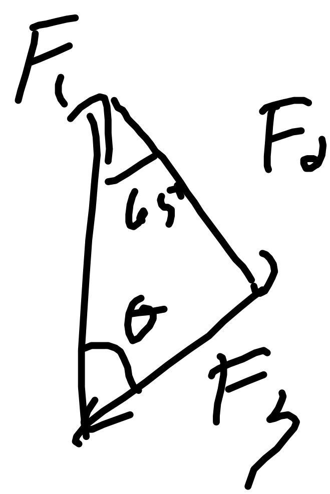
V_r at α N of E

Q2

a)



Free body



Vector Addition

b) $F_3^2 = F_1^2 + F_2^2 - 2F_1F_2\cos 65^\circ$

$$\frac{\sin 65}{F_3} = \frac{\sin\theta}{F_2}$$

F_3 at $180 + \theta$

c) $F_{1x} = 0$

$F_{1y} = F_1 = 20.30-4$

$F_{2x} = F_1 \sin 65^\circ$

$F_{2y} = -F_2 \cos 65^\circ$

$F_{3x} = -F_{2x}$

$F_{3y} = \left|F_1 - \left|F_{2y}\right|\right|$

Projectile Quiz

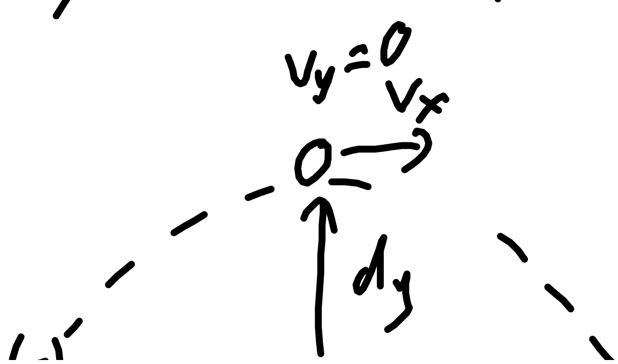
a)

$V_y = V \sin\theta = 3.54\ m/s$

$V_x = V\cos\theta = 5\cos 45 = 3.54\ m/s$

V_x is constant $\quad a_y = -9.80\ m/s^2$

b)



$a = g = -9.8\ m/s^2$

$V_{yi} = 3.56\,m/s$

$$V_{yf}^2 = V_{yi}^2 + 2g\,d_y$$

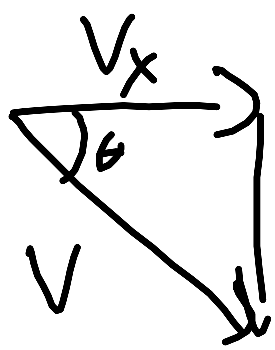
$$d_y = \frac{-3.5}{2(-9.8)}$$

$$= \boxed{0.639\,m}$$

c) $$t = \frac{V_f - V_i}{a} = \frac{0 - 3.54}{-9.8} = \boxed{0.361\,s}$$

d) $$V_{yf} = gt + V_{yi} = -9.8(0.5) + 3.54$$

$$= -1.36\,m/s$$



$$V = \sqrt{V_x^2 + V_y^2}$$

$$= \sqrt{1.36^2 + 3.54^2}$$

$$V = \boxed{3.79\,m/s}$$

$$\theta = \tan^{-1}\frac{3.36}{3.54} = \boxed{21.6^\circ \text{ below horizontal}}$$

e) $d_x = V_x t$

$= 3.54\,m/s\,(0.361\,s) \times 2$

up + down

$$= \boxed{2.55\,m}$$

f) $d_x = V_x t$

$$\cancel{d_y}^{\,0} = \frac{1}{2} g t^2 + V_{yi} t$$

$$0 = \frac{1}{2} g t + V_{yi}$$

$$t = \frac{d_x}{V_x}$$

$$0 = \frac{1}{2} g \frac{d_x}{V_x} + V_{yi}$$

$$\frac{g\, d_x}{2V_x} = -V_{yi}$$

$$d_x = -\frac{2V_{yi}V_x}{g} = \frac{-2V\sin\theta\, V\cos\theta}{g}$$

$$d_x = -\frac{2V^2 \sin\theta\cos\theta}{g}$$

$$10 = \frac{2V^2 \sin 45 \cos 45}{g}$$

$$\boxed{V = 9.90\,m/s}$$

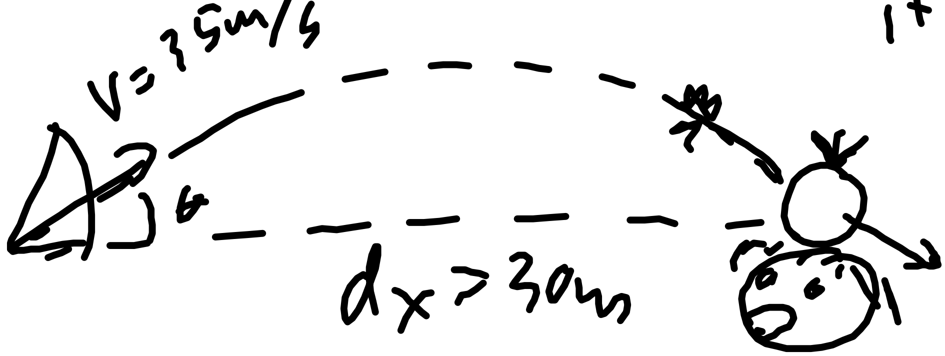
$$2\sin\theta\cos\theta = \sin 2\theta$$

$$\boxed{d_x = -\frac{V^2 \sin 2\theta}{g}}$$

range equation

- only works if $d_y = 0$

Q45



$$30 = \frac{35^2 \sin 2\theta}{9.8}$$

$\boxed{\theta = 6.9^\circ}$ $\quad 47.1^\circ$

Dynamics: Chapter 4

Write out Newton's 3 laws
- simplified name
- full description of the law
- example

page 1 of Free-body diagrams worksheet
set Fg as 2.0 cm and make all vectors to scale with Fg

Newton's First Law:
Law of Inertia
- Objects move at a constant speed in a straight line (constant velocity) unless external forces are unbalanced.
- example: a car at rest requires a force to accelerate.
- light moving through empty space (no friction) will travel forever at the same speed. This is true of spaceships as well.

balanced: when the vector sum of all forces is zero.

$F_{net} = \Sigma F$ (vector sum of all)

Second Law

Law of acceleration

F_{net}=ma = $\Delta p/\Delta t$ (rate of change in momentum)

example: if I push on a 1.0 kg cart it accelerates at 2.0 m/s^2 with a 2.0 N force and negligible friciton, but if I push on a car, mass 1000kg with 2.0 N of force - it will not overcome friction, but even if friction is negligible, then the acceleration will be a=F/m = 2N/1000kg = 0.0020 m/s^2

Newton's Third Law

Action-reaction Law

For every force object A acts on object B, object B reacts with an equal and opposite force on A.

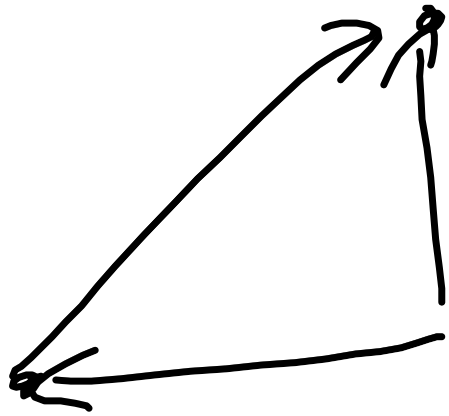
- on 2 different objects.

eg. the reaction force to the gravitational pull on you, is an equal and opposite pull of gravity on the Earth.

What causes the Normal force (force perpendicular to surfaces)? It reacts to you pushing on the ground.

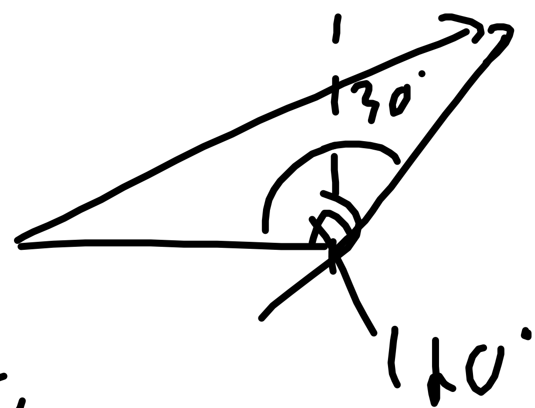
p91 Questions 1-4,7,9

p92 Problems 1-17odds

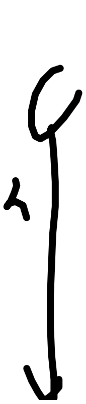


$V\Delta = V_f - V_i$

Vector



$d = \frac{1}{2} g t^2$



$d_1 = \frac{1}{2}gt^2$

$d_2 = -\frac{1}{2}gt^2 + v_i t$

$d_1 + d_2 = 30$

$\left|\frac{1}{2}gt^2\right| + \frac{1}{2}gt^2 + v_i t = 30$

$t = \frac{30}{20} = 1.5s$

Dynamics: Chapter 4

Write out Newton's 3 laws
- simplified name
- full description of the law
- example

page 1 of Free-body diagrams worksheet
set Fg as 2.0 cm and make all vectors to scale with Fg

Newton's First Law:
Law of Inertia
- Objects move at a constant speed in a straight line (constant velocity) unless an external unbalanced set of forces acts on the object.
- balanced: vector sum of all forces adds to zero.

$F_{net} = \Sigma F$ sum of all forces - need vector diagram or components

eg. the pen will roll until friction slows it down.
A spaceship will fly forever in space as there is no friction.

Newton's Second Law
Acceleration Law
$F_{net} = ma = \Delta p/\Delta t$ rate of change in momentum

eg. You push a 1.0 kg cart with 2.0N of force, so it accelerates at $2.0 m/s^2$ if friction is negligible.
If I applied the same force to a 1000 kg car, the friction will be too great for any acceleration. If the car was perfectly frictionless, then it would accelerate at $a=F/m = 2.0N/1000kg = 0.0020 m/s^2$.

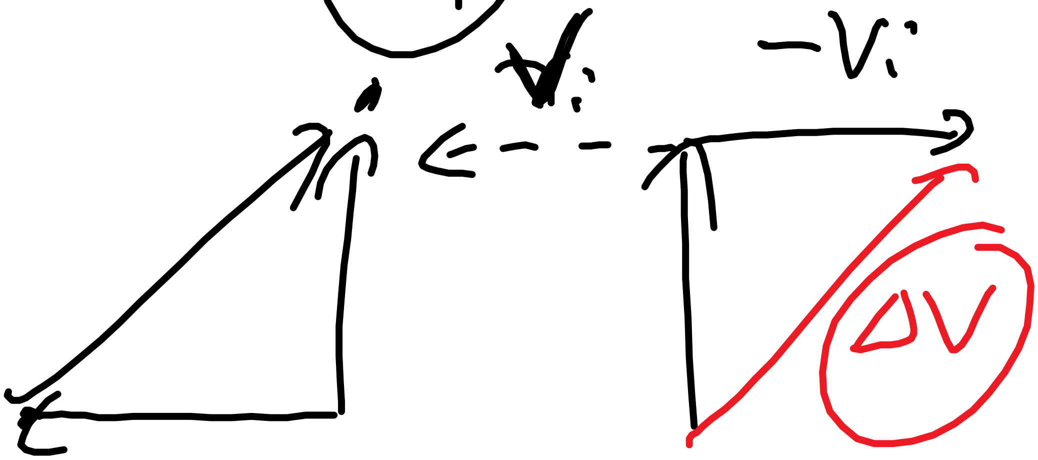
Newton's Third Law
Action-Reaction Law
If one object applies a force on a second object, the second object applies an equal and opposite force on the first object.

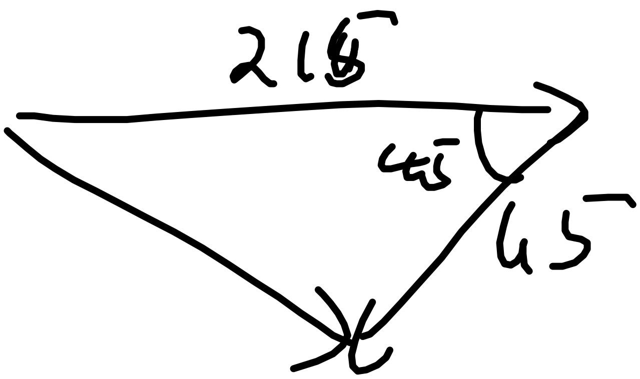
- always 2 objects.
- eg. the normal force is a reaction force to your foot pushing on the ground.
- gravity pulls on you, what is the reaction force to that pull? Your pull of gravity on the Earth.

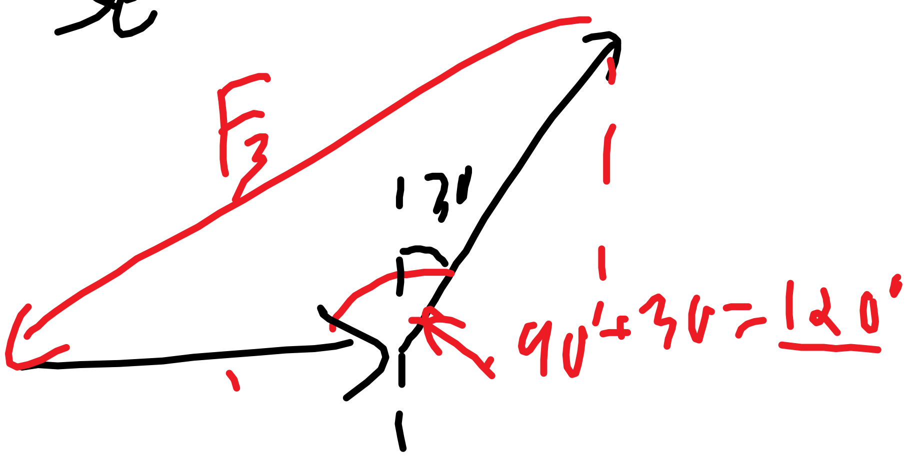
7 000 000 000 people x 100kg x 10Nkg
7 x 10^{12}N of force on the Earth, mass $6x10^{24}$kg, accelerate at 1 x 10^{-12} m/s^2

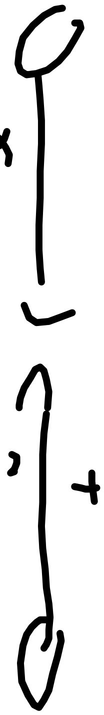
p91 Questions 1-4,7,9
p92 Problems 1-17odds

$$\Delta x = x_f - x_i$$









$d_1 = \frac{1}{2} g t^2$

$d_2 = \frac{1}{2} g t^2 + v_i t$

$|d_1| + d_2 = 30$

$\cancel{\frac{1}{2} g t^2 + \frac{1}{2} g t^2} + v_i t = 30$

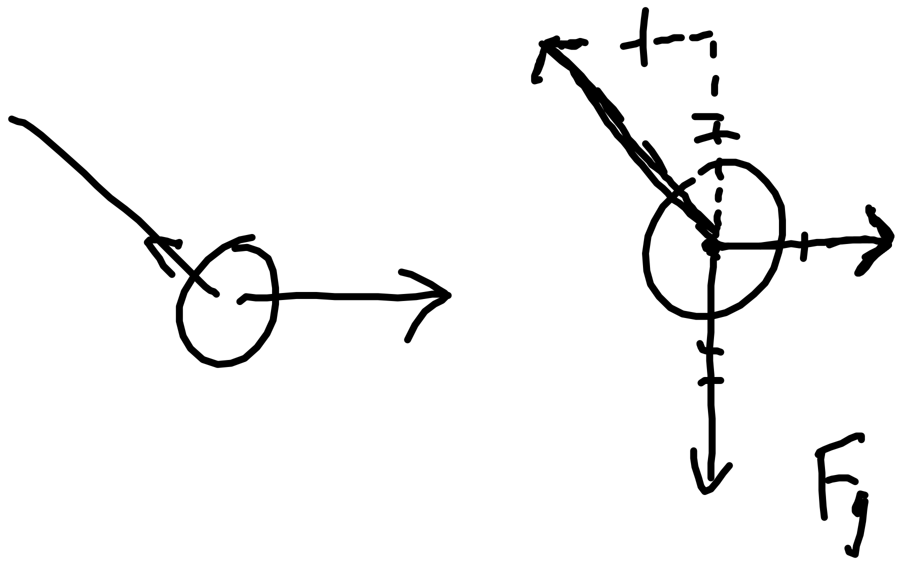
$t = \frac{30}{20} = 1.5$

Dynamics: Chapter 4

Write out Newton's 3 laws
- simplified name
- full description of the law
- example

page 1 of Free-body diagrams worksheet
set Fg as 2.0 cm and make all vectors to scale with

Fg



Newton's First Law
Law of Inertia
Objects move at a constant speed in a straight line (constant velocity) until an unbalanced set of external forces acts on it.
unbalanced = vector sum is not zero

$F_{net} = \Sigma F$ vector addition diagram or add all the components

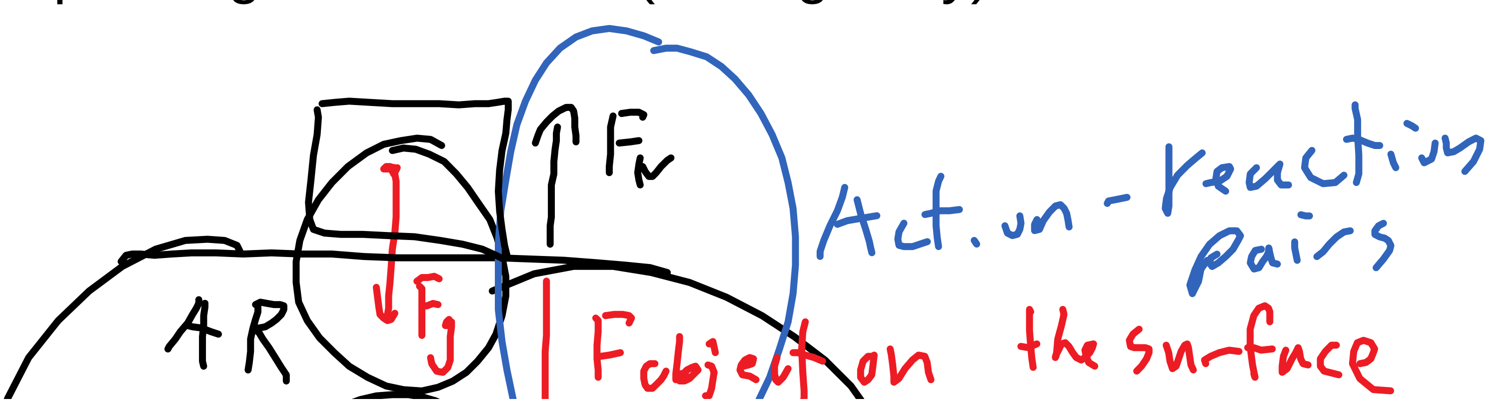
example: stuff slides but stops because of friction
- spaceships don't slow down because there are no frictional forces in space.

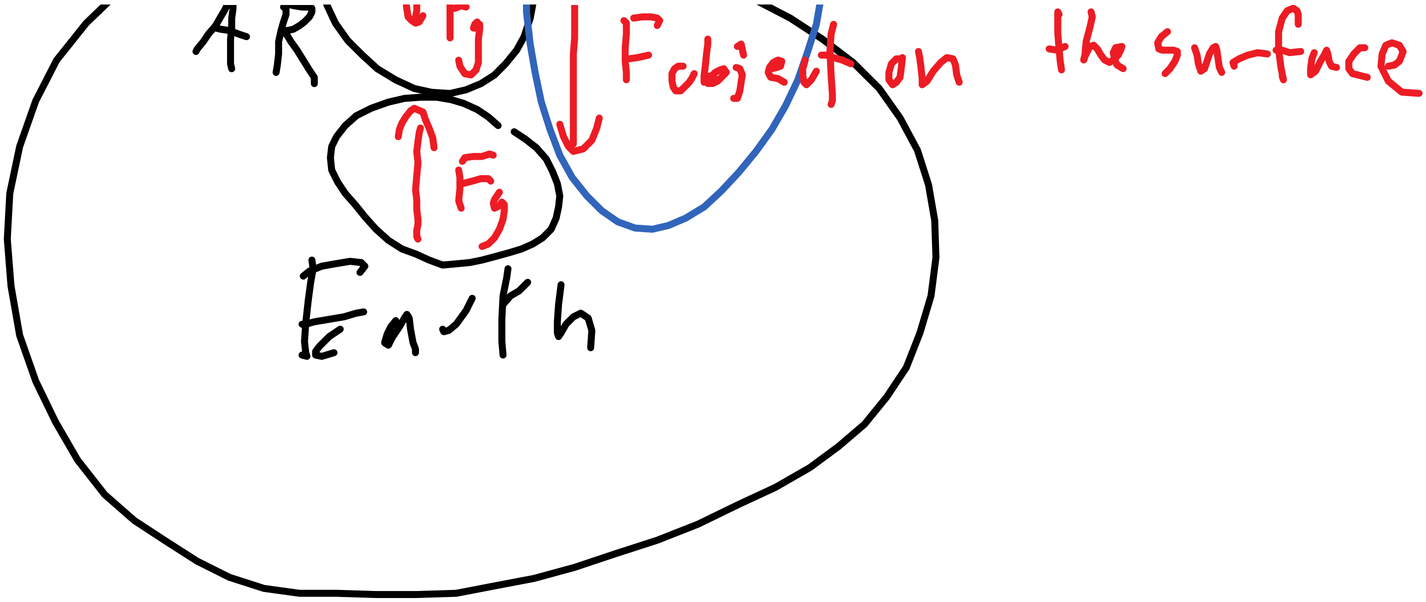
Newton's Second Law
Law of acceleration

F_{net} = ma = ΣF =Δp/Δt the rate of change in momentum (p=mv)
m is mass in kg
a is acceleration in m/s^2
F is force in N
eg. If you pull a 1.0kg cart with 2.0N it will accelerate at 2.0m/s^2 if friction is negligible.
If you applied the same force to a 1000 kg car, what happens?
Friction prevents acceleration.
what if we had a 1000 kg car with perfectly frictionless wheels?
It would accelerate at a=F/m = 2.0N/1000 kg = 0.0020m/s^2

Newton's Third Law
Action - Reaction Law
For every force an object applies on a second object, the second object responds with an equal and opposite force on the first object.

eg. the Normal force is a reaction for to an object pushing on a surface. (NOT gravity)





eg. a 100kg teacher jumps and is pulled down with about 1000N of force, resulting in a $10 m/s^2$ acceleration.
the Earth gets pulled with the same force but the mass is 5.98×10^{24}kg
so it accelerates at $1000N/6x\ 10^{24}kg = 2x10^{-22} m/s^2$

Block 1-1

p91 Question
1 lift on Earth vs Moon
less force on Moon because less gravitational field strength g
$F_{lift} > F_g = mg$
throw on Earth vs Moon
horizontal force is independent of g so it would be the same force.

2 The kid is accelerated, so their feet experience a force.

- your body is at rest, so it will tend to stay at rest even though your feet move.
- the force is off centre so it causes rotation.

3. your head is at rest, so as your body accelerates forward your head seems to go backwards relative to your body. It actually just stays at rest relative to the ground.
4. a Yes, there is a change in velocity so a force was required. The ground pushed up

on the ball, the normal force. $F_N > F_g$.

7. $a=0$ so $F_{net}=0 = \Sigma F = 0$ so as long as the vector sum adds to 0 $a=0$. So there can be balanced forces.
9. impossible for $a=0$ if there is only one force projectiles have only gravity action on the object.
   v can still be zero

Pulley Problems (Newton's second law)

big idea:

$F_{net}=ma$

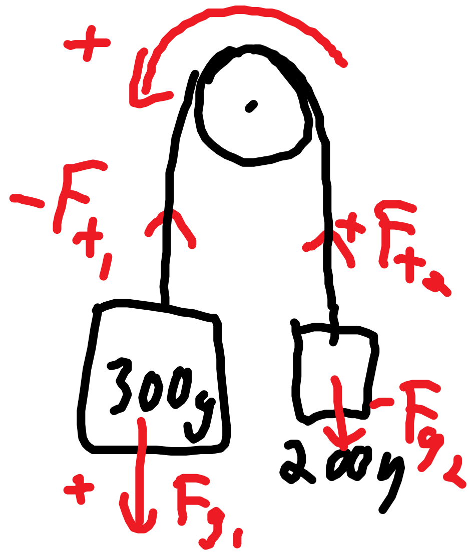
tension in the string is equal at both ends if the pulley and string have negligible mass and friction.

to calculate the acceleration of the system, find the sum of all forces= total mass x a

to determine the tension force, look at part of the system

eg. a 300. g mass and a 200. g mass are suspended over a pulley on a string. determine the acceleration of each mass

and the tension in the string at each end.



$$F_{t_1} = F_{t_2}$$

Classwork: p93-94 Problems 19-31 odds

$$\Sigma F = ma$$

whole system

whole system

$$+F_{g_2} \cancel{- F_{t_1} + F_{t_2}} - F_{g_1} = (m_1 + m_2)a$$

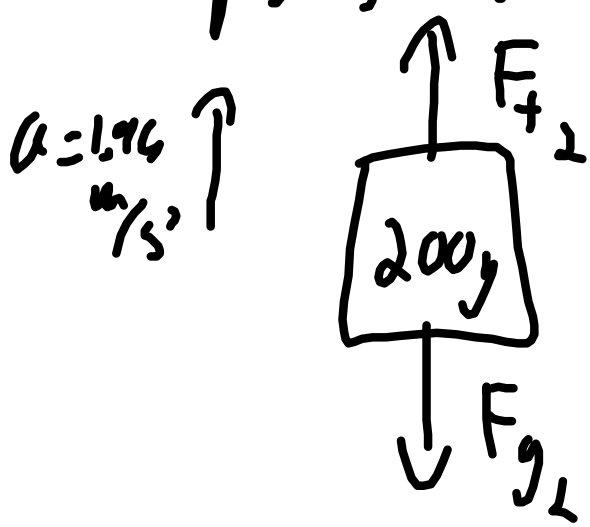
$$m_2 g - m_1 g = (m_1 + m_2)a$$

$$\boxed{a = \frac{(m_2 - m_1)}{(m_1 + m_2)} g}$$

$$a = \frac{(0.30kg - 0.20kg)}{0.3kg + 0.2kg} 9.8 m/s^2$$

$$\boxed{a = 1.96 m/s^2}$$

for tension look at part of system



$$\Sigma F = ma$$

$$F_{t_2} - F_{g_2} = m_2 a$$

$$F_{t_2} = m_2 a + m_2 g$$

$$= 0.2(1.96 + 9.80)$$

$$= \boxed{2.35 N}$$

test experimentally

$d = 1.0m$

$a = 1.96 m/s^2$ $\quad d = \frac{1}{2} a t^2$

$v_i = 0$

$t = ?$ $\quad t = \sqrt{\frac{2d}{a}}$

$$t = \sqrt{\frac{2(1.0m)}{1.96 m/s^2}} = \boxed{1.0s}$$

Block 1-2

p91

Question 1-4,7,9

1. Lifting a 10kg object on Moon vs Earth
   less force to lift on the Moon than on Earth
   F_{lift} >/= to $F_g = mg$
   earth 10x9.8=98N moon 10x1.6=16N

Horizontal force is independent of g, the gravitational field strength.
F=ma

2. Inertia - tendency of the child to stay at rest. Force on the feet accelerate the feet while the body stays still.
   - the force is off centre so it causes a torque(force a distance from rotation point) causing rotation.
3. same as 2, your head tends to stay at rest while your body gets accelerated by the seat. Your head doesn't really move backwards, the car and your body move forwards.

4 a. Yes - there is a change in velocity and F=ma

b) the ground pushes up on the ball(equal to the force the ball pushes on the ground) - we call the perpendicular component of the ground force, the normal force, F_N.

7. a=0 v is constant
F=ma so if a=0 ~~then f=0 NO~~

F=ma so if a=0 t~~hen f=0 NO.~~

F_{net}=ma=ΣF so as long as the vector sum adds to zero, a=0

F_g and F_N cancel for example

9. F is not 0 so acceleration can't be zero. but v can be 0 for an instant - think of throwing a ball straight up, top point v= 0 but F=F_g

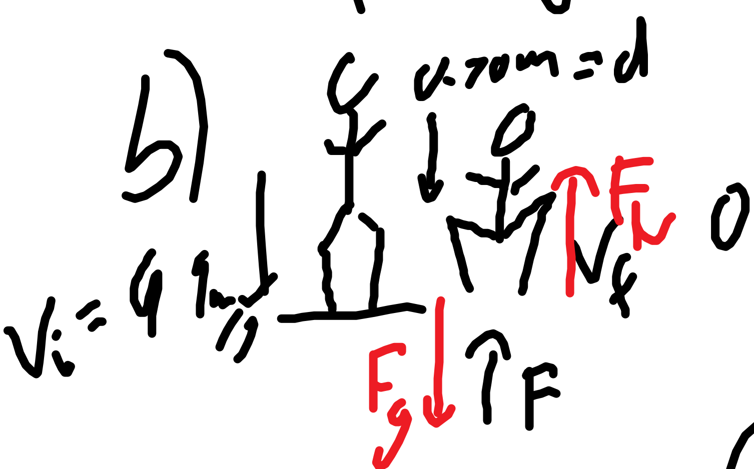
$v_i = 0 \quad v_f = ? \quad a = 9.80\,m/s^2$

$d = 5.0\,m$

$v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{2(5)(9.8)} = 9.9\,m/s$

b)



$\boxed{F_{net} = ma = \Sigma F}$

$a = \frac{v_f^2 - v_i^2}{2d} \quad \frac{98}{2(0.7)}$

$F_g \downarrow \mid F$

$$a = \frac{v_f^2 - v_i^2}{2d} \quad \frac{98}{2(0.7)}$$

$$a = 70\,m/s^2$$

$$ma = F_N - F_g \rightarrow F_N = ma + mg$$

$F_{legs} = F_N$

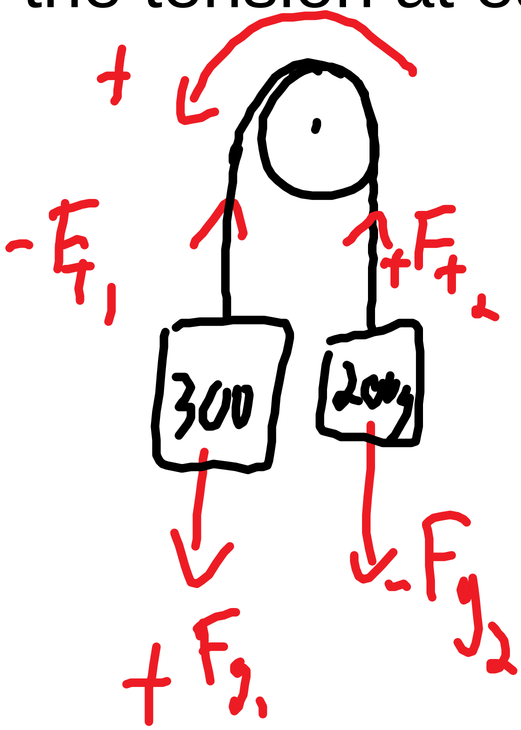
$$F_N = m(a + g)$$

$$F_N = 50kg(70\,m/s^2 + 9.80\,m/s^2)$$

$$= 3990\,N \rightarrow \boxed{4.0 \times 10^3\,N}$$

Pulley Problems
Newton's second Law
For a string over a pulley with negligible friction and mass, the tension in the string is equal at both ends.
eg. a 300 g mass and a 200 g mass

are connected by a string and suspended over a pulley. When you let go, what is the acceleration of each mass and the tension at each end of the string.



$|F_{T_1}| = |F_{T_2}|$

to calculate acceleration, look at the whole system
to determine tension, look at part of the system

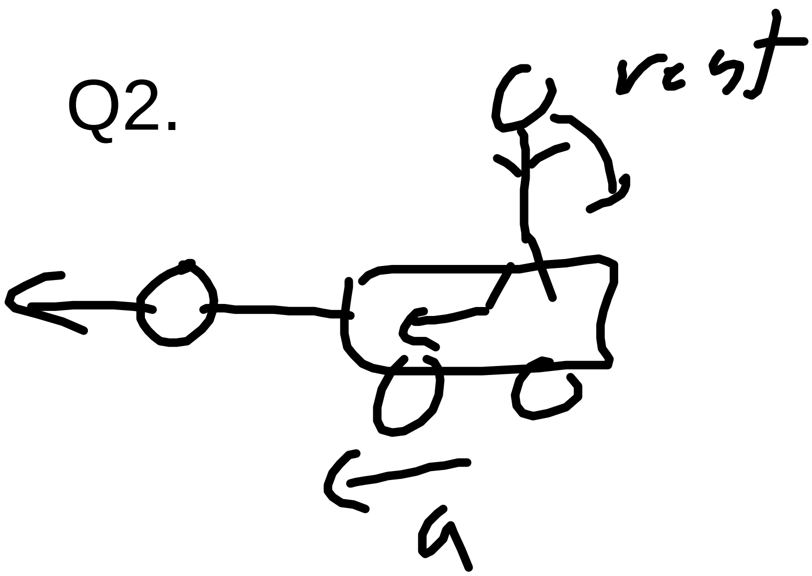
p91
Questions 1-4,7,9

1. Force to lift on Earth vs Moon

Earth requires more force because the gravitational field strength, g, is stronger.
$F >/= F_g = mg = 10kg \times 9.8N/kg$
$= 98N$ Earth
$F >/= F_g = mg = 10kg \times 1.6N/kg$
$= 16N$ Moon

Force to throw Earth vs Moon horizontal motion is independent of sideways motion (Earth with have a touch more air resistance)

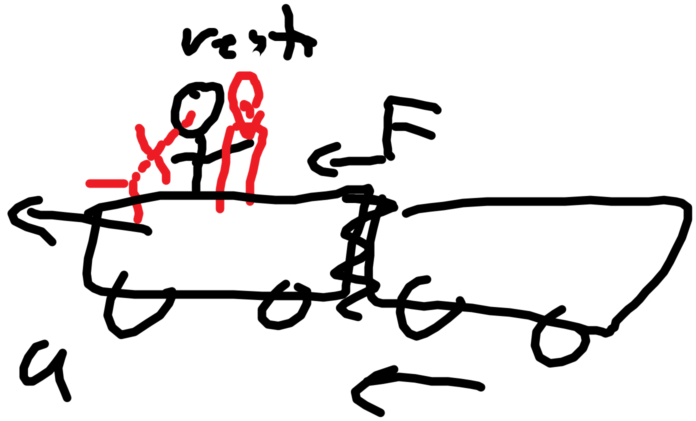
Q2.



inertia - the child at rest tends to stay at rest while the feet accelerate.

- the force on the feet cause a torque, resulting in rotation of the child.

Q3



Q4

a) yes - velocity changes so a so F_{net}

b) the ground pushes up with F_N - normal force, $F_N >> F_g$

$F = ma$

$\frac{\Delta v}{\Delta t}$

7 a=0, since F=ma, if a=0 then no F then ~~F_{net}~~ = 0 so the sum of all force =0 but the individual forces can be non-zero.

eg. gravity is pulling on you but it is

balance by the normal force of the ground/chair.

9 on one F so F_{net} is F is not zero.

so a is not zero.

so it can have an instantaneous v=0, for example when you throw something up. v=0 at the top point while F=Fg

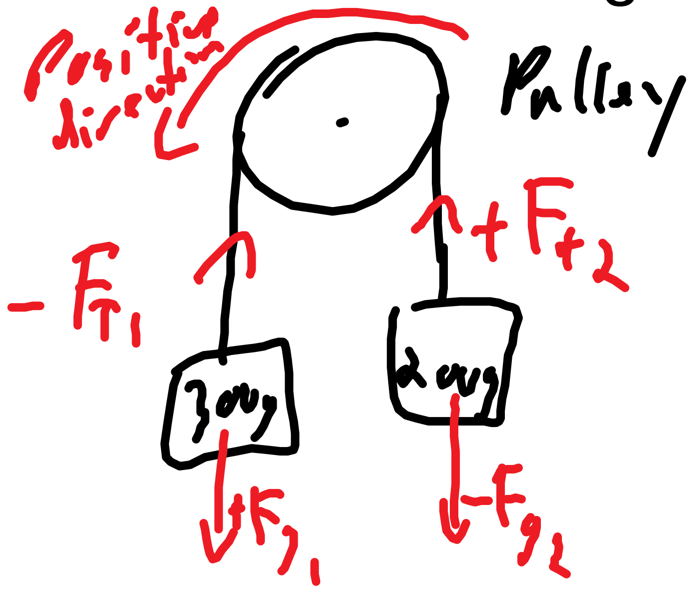
Pulley Problem

Big idea $F_{net}=ma=\Sigma F$

tricky idea: the tension in the string is equal at each end if the pulley and string are massless and frictionless.

eg. a 300g mass and a 200g mass are connected by a string over a pulley. When you let go, determine the acceleration and tension of each object

and each end of the string.



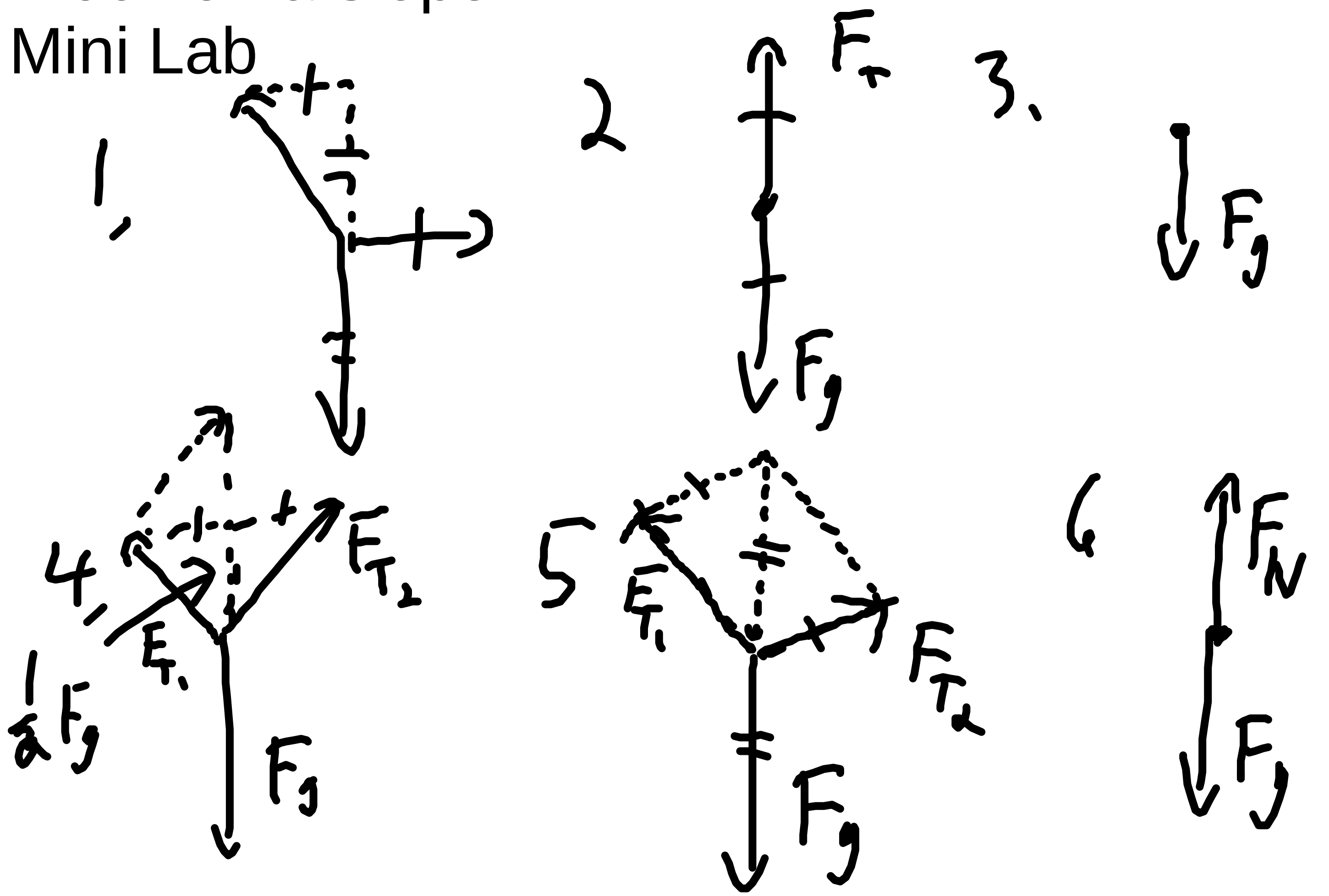
To find the acceleration, look at the whole system: Ft cancels

To find Ft: look at part of the system

p93-94 Problems 19-31 odds

Thursday, October 29, 2015
8:42 AM

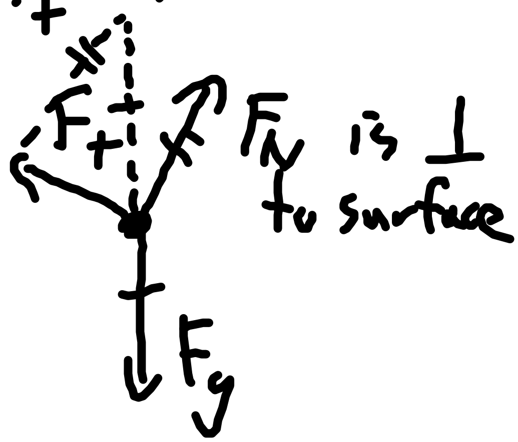
Free Body Diagram sheet p1
Rolling down slope
Block on a slope
Mini Lab



F_N is normal force
F_s is force of the surface
F_t is tension
F_g is weight = force of gravity

g is gravitational field strength
F_f is force of friction

7



8

Friction and Slopes

F_f is the force of friction - a force between two surfaces opposing sliding motion. (opposes v usually)
friction is proportional to the normal force, F_N, is the force perpendicular to a surface by the surface.
Force of the surface is the vector sum of friction and normal force, F_s.

The constant of proportionality between the frictional force and the

normal force is μ.
static friction - where the object is not moving. μ_s
kinetic friction is where the surfaces are sliding past each other. μ_k
Coefficient of friction depends on the surfaces. Assume it doesn't depend on velocity much.
Usually static friction is greater that kinetic.

$F_f = \mu F_N$

eg. I lift a wooden block and the scale reads 3.0N. When I pull it sideways it just starts moving when I pull at 1.8N but when it is moving at a constant speed, the scale reads 1.5N.

a) what is the mass of the block?
b) what are the coefficients of static and kinetic friction?
c) draw a free body diagram
d) if I pulled with 2.5N, what is the

acceleration of the block?

e) draw a free body diagram of the block on a slope, angle θ to the horizontal i) no friction ii) friction stationary iii)friction sliding up the slope iv) friction sliding down the slope

a) $F_g = mg$

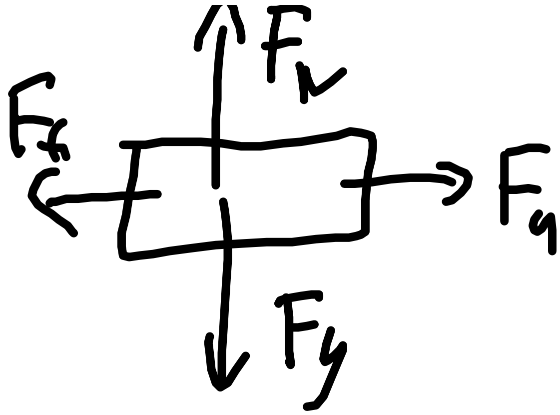
$$m = \frac{3.0\,N}{9.80\,m/s^2}$$

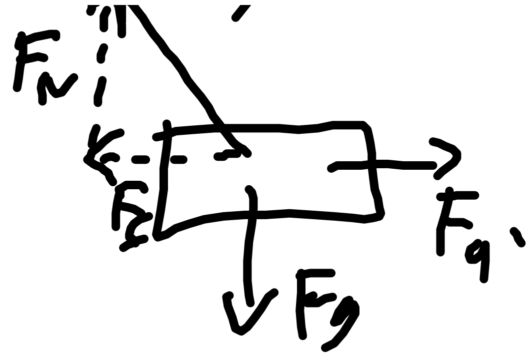
$$\boxed{m = 0.31\,kg}$$

b) $F_f = \mu F_N$

$$\mu_s = \frac{F_f}{F_N} = \frac{1.8\,N}{3.0\,N} = \boxed{0.60}$$

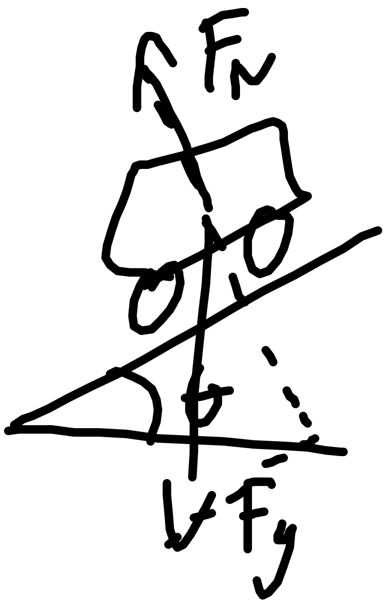
$$\mu_K = \boxed{0.50}$$

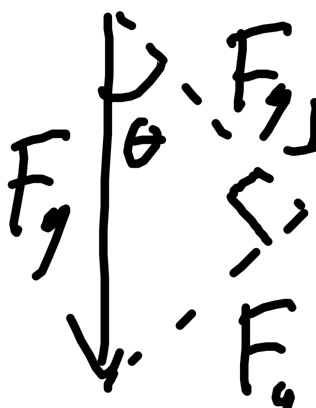
c) 



$$F_{net} = ma = 2.5N - 1.5N$$

$$a = \frac{1.0N}{0.31kg} = \boxed{3.3 m/s^2}$$

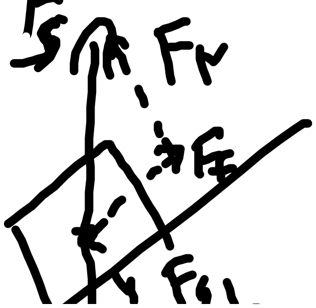
e) 



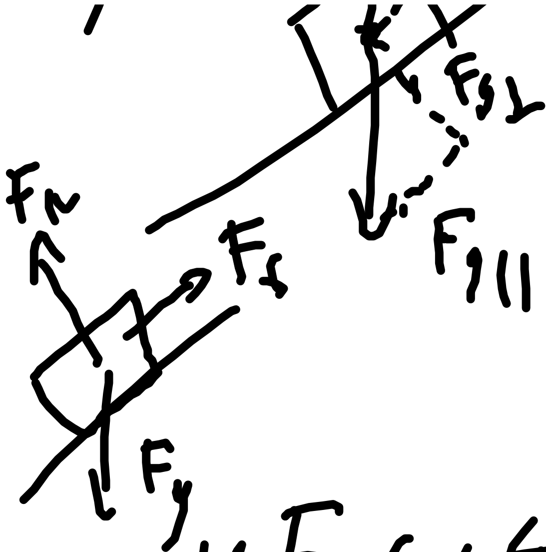
$$F_{g\perp} = F_g \cos\theta$$

$$F_{g\parallel} = F_g \sin\theta$$

$$F_N = F_{g\perp} = F_g \cos\theta$$

(i) 

$$F_N = F_{g\perp} = F_g \cos\theta$$



$$F_N = F_{g\perp} = F_g \cos\theta$$

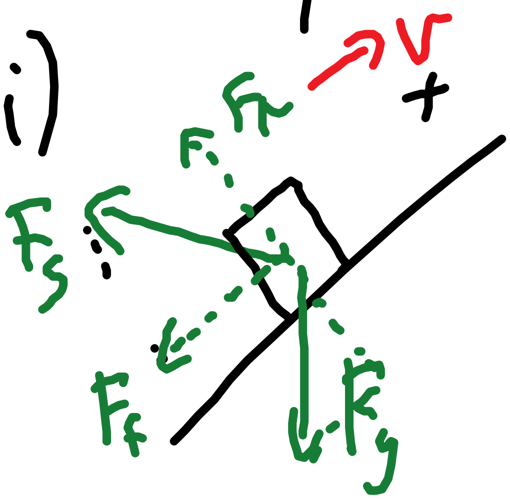
$$F_f = F_{g\parallel} = F_g \sin\theta$$

$$\mu F_N = \mu F_g \cos\theta$$

$$\mu F_g \cos\theta = F_g \sin\theta$$

$$\mu = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

iii)

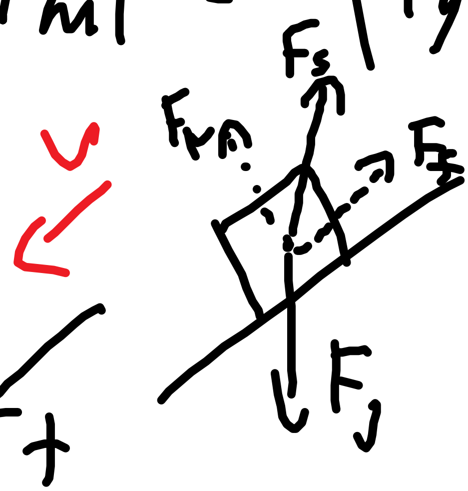


$$F_{net} = \sum F$$

$$F_{net} = -(F_{g\parallel} + F_f)$$

$$F_{net} = -(F_g \sin\theta + \mu F_g \cos\theta)$$

iv)

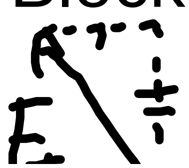


$$F_{net} = F_g\sin\theta - \mu F_g\cos\theta$$

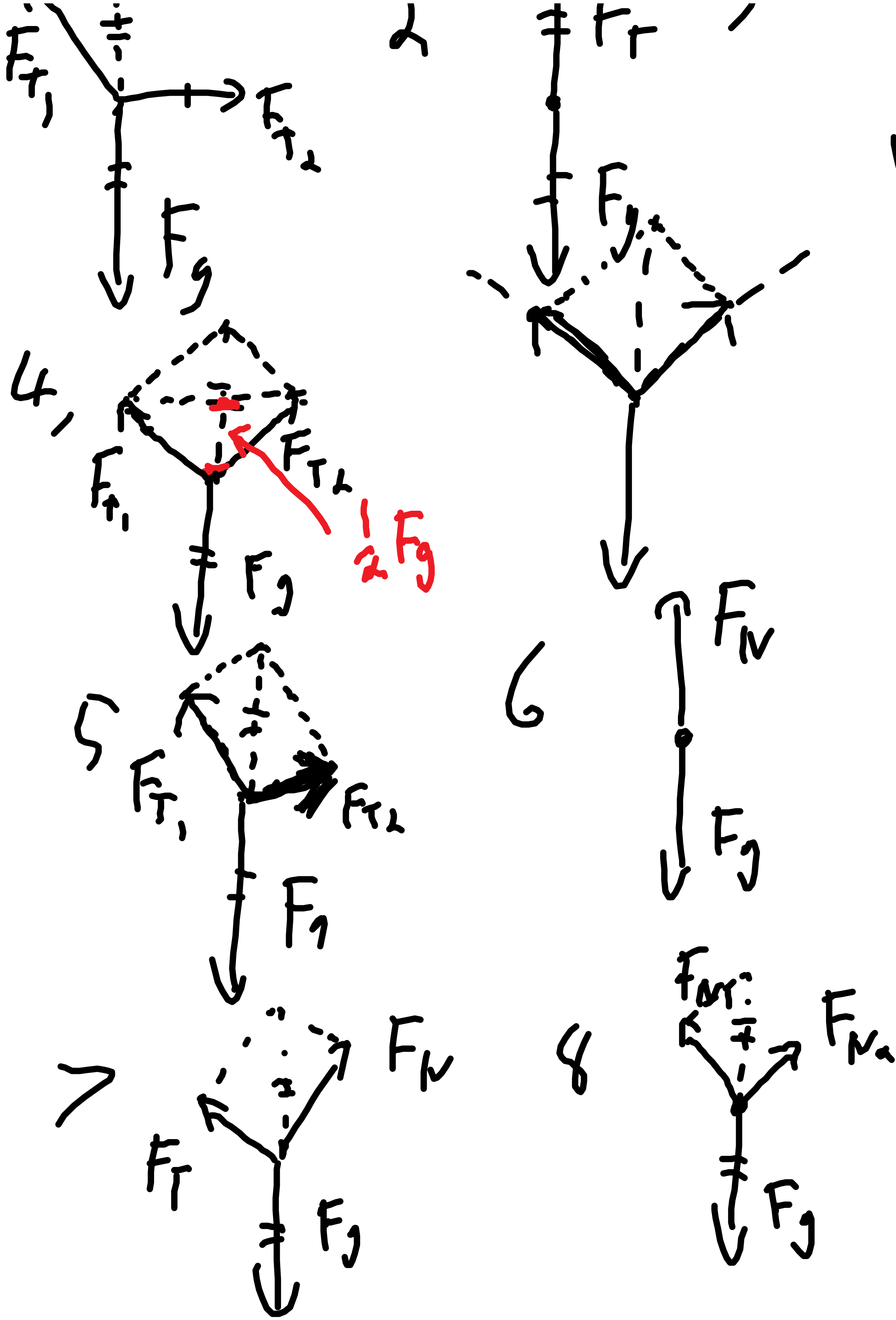
eg. the 3.0N block is now placed on a 25.0º to the horizontal slope. What is the acceleration of the block if

a) the surface is frictionless
b) the coefficient of kinetic friction is 0.20 and block is sliding down
c) the same coefficient but the block is sliding up
d) what is the maximum angle of slope the block can sit on without sliding if the static coefficient is 0.30?
e) How long will it take for the block in c to slide up and slide back to the same point if you give it an initial speed of 2.0 m/s?

1-1
Free Body Diagram sheet p1
Rolling down slope
Block on a slope



2 F_r 3 4



Types of Forces:

F_g is the weight = force of gravity
g is the gravitational field strength
$F_g = mg$
F_t is the tension - same magnitude at each end of a massless string.

The textbook labels the normal force and frictional forces as separate forces.
They are components of the surface force, F_s, the force the surface pushes on an object.
Normal force, F_N, is the perpendicular component of the surface force.
Frictional force, F_f, is the component of the frictional force along the surface.
The force opposing sliding motion between two surfaces.
The frictional force is determined by the normal force (proportional to the pressure between the surfaces)
and type of surfaces, related to the coefficient of friction, μ.
$F_f=\mu F_N$

static friction, μ_s is the friction when the object is not moving

kinetic friction, μ_k is the friction when moving. (assume v doesn't change friction much)

static friction is usually greater.

eg. You lift a wooden block with a force scale and it reads 3.0N. You pull the block on a wooden surface and it requires 1.8N to get it moving and then 1.5N to keep it moving at a constant speed. Determine

a) mass of the block
b) coefficient of static friction
c) coefficient of kinetic friction
d) acceleration if you pull it at 2.5N
e) draw a free body diagram of block pulled
  i) at a constant speed
  ii) at 2.5 N

iii) tilt the wooden slope and put a cart with frictionless wheels on the slope
iv) put the block on the slope stationary
v) have the block moving up the slope (initial speed but no other forces than gravity, friction and surface force)
vi) have the block sliding down the slope

a) $m = \frac{F_g}{g} = \frac{3.0N}{9.8N/kg} = \boxed{0.31kg}$

b) $\mu_s = \frac{F_f}{F_N} = \frac{1.8N}{3.0N} = \boxed{0.60}$

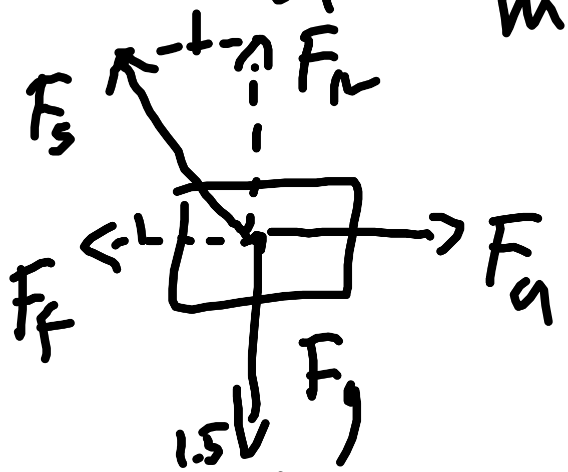
c) $\mu_K = \frac{1.5}{3.0} = \boxed{0.50}$

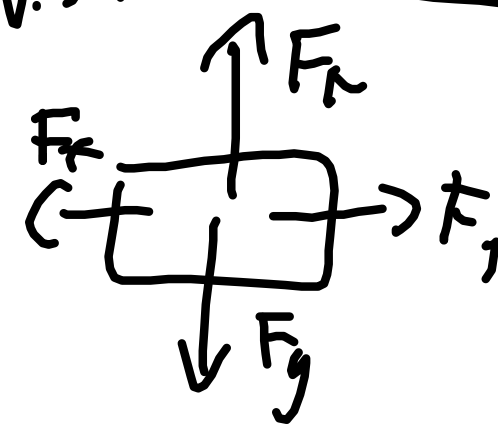
d) $F_{net} = 2.5N - 1.5N = 1.0N$

$a = \frac{F_{net}}{m} = \frac{1.0N}{0.31kg} = \boxed{0.33m/s^2}$

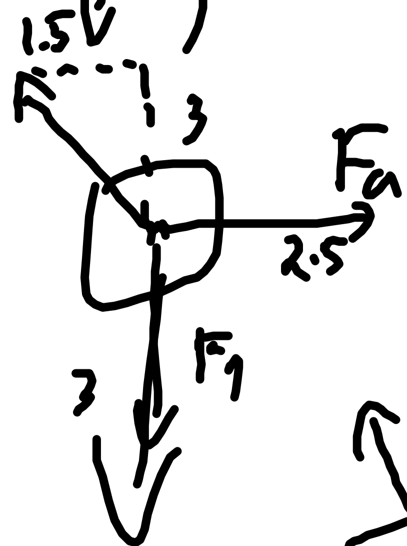
e)

i)

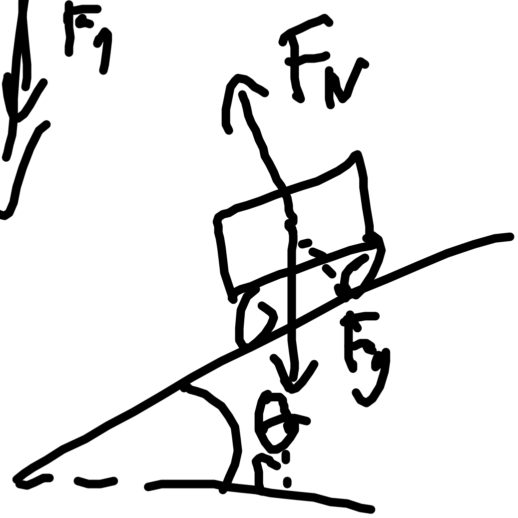


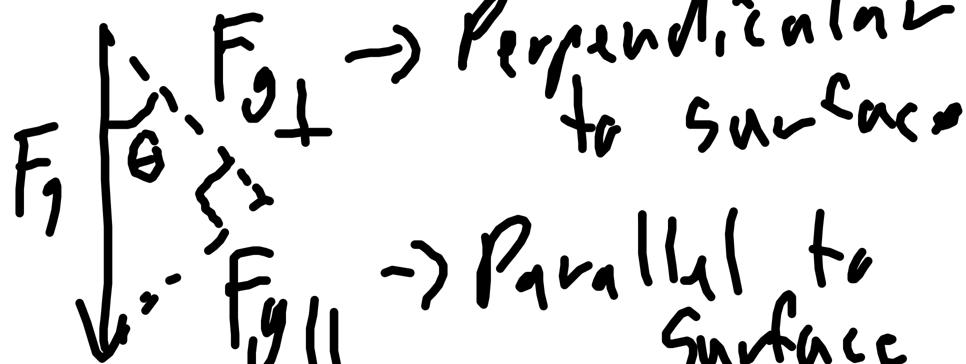


ii)



iii)





* $\boxed{F_{g\perp} = F_g \cos\theta}$

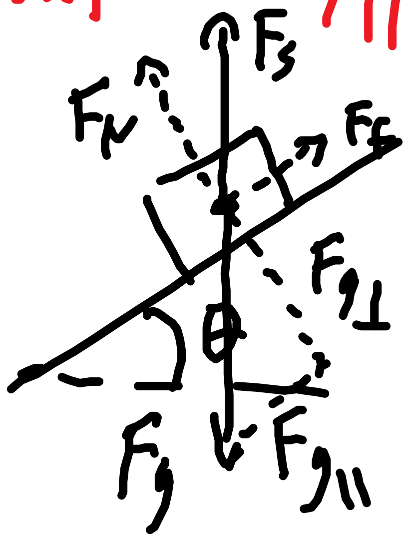
* $$\boxed{\begin{aligned} F_{g\perp} &= F_g\cos\theta \\ F_{g\parallel} &= F_g\sin\theta \end{aligned}}$$

$$F_N = F_{g\perp} = F_g\cos\theta$$

$$F_{mt} = F_{g\parallel} = F_g\sin\theta$$

No friction

iv)



$$F_N = F_{g\perp} = F_g\cos\theta$$

$$F_f = F_{g\parallel}$$

static only

$$F_f = F_g\sin\theta$$

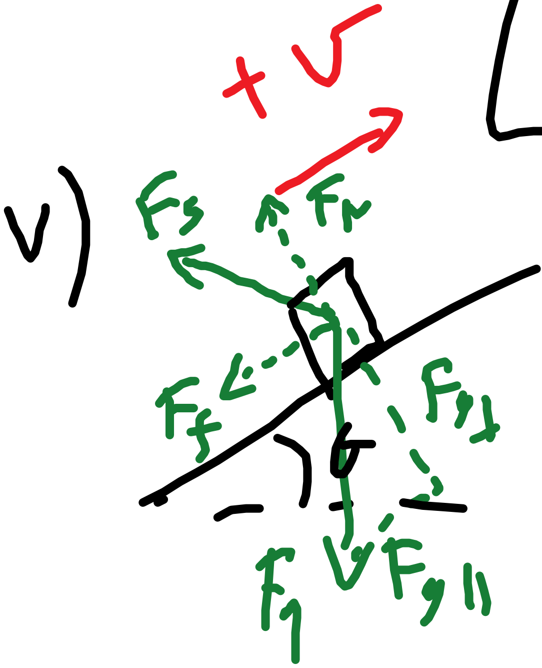
but $F_f = \mu F_N = \mu F_g\cos\theta$

$$\mu \cancel{F_g}\cos\theta = \cancel{F_g}\sin\theta$$

$$\mu = \frac{\sin\theta}{\cos\theta}$$

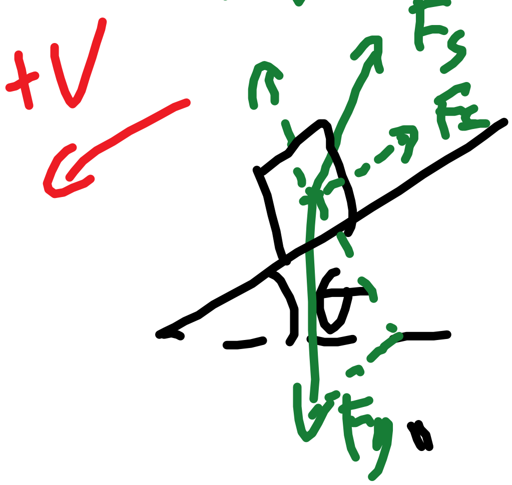
$$\boxed{\mu_s = \tan\theta}$$

v)



$$F_{net} = -(F_{g\parallel} + F_f)$$

$$F_{net} = -(F_g \sin\theta + \mu F_g \cos\theta)$$



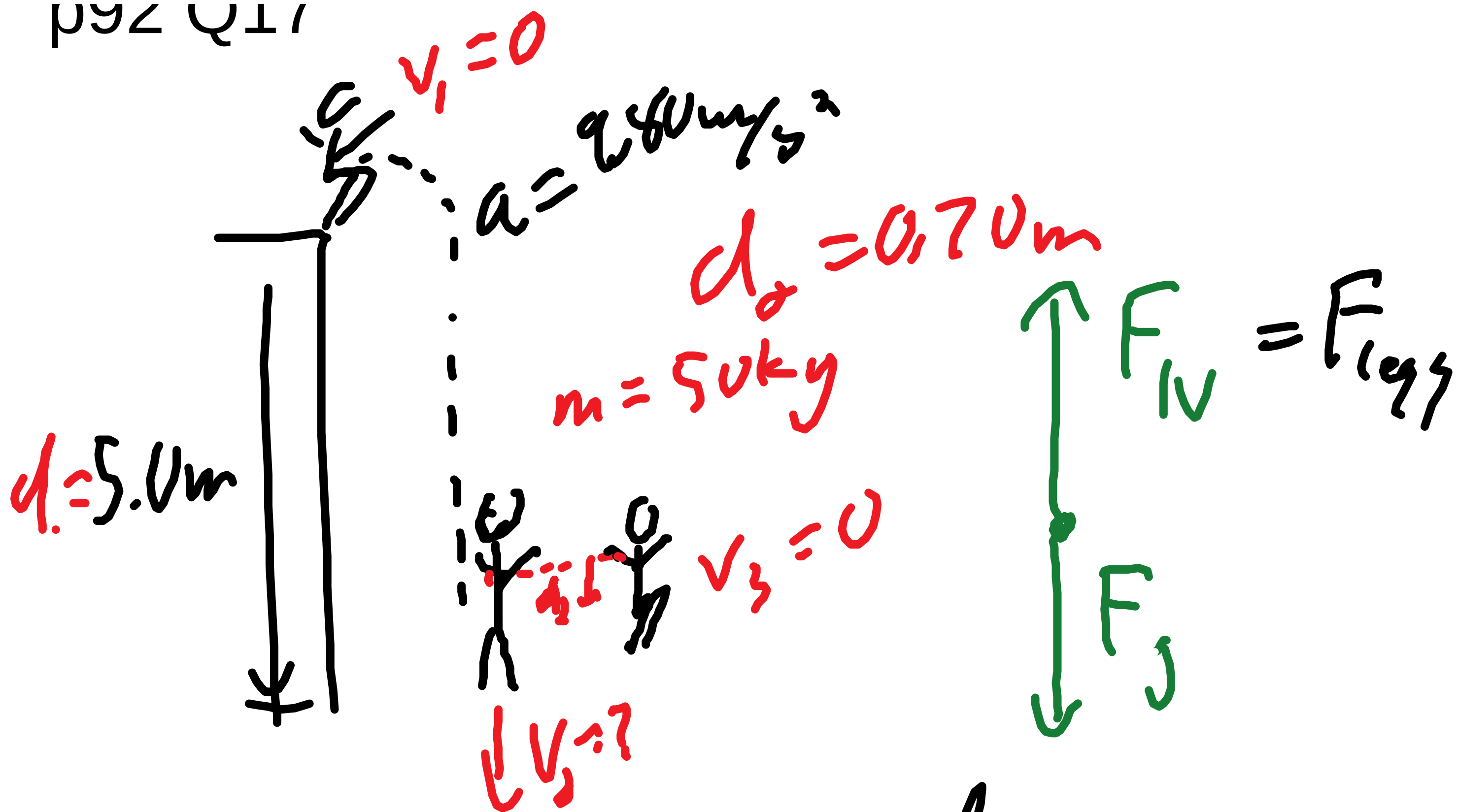
$$F_{net} = F_{g\parallel} - F_f$$

$$F_{net} = F_g \sin\theta - \mu F_g \cos\theta$$

p92 Q17

$v = 0$

p92 Q17



a) $v_f^2 = v_i^2 + 2ad$

$$v_f = \sqrt{0 + 2(9.8\,m/s^2)(5\,m)} = \boxed{9.9\,m/s}$$

b) $F_{net} = ma = \Sigma F$

$$v_f^2 = v_i^2 + 2ad$$

$$a = \frac{0 - 98.0\,m^2/s^2}{2(0.7\,m)}$$

$a = 70\,m/s^2$

$F_{net} = ma = 50kg \times 70\,m/s^2$

$= 3500N = \Sigma F$

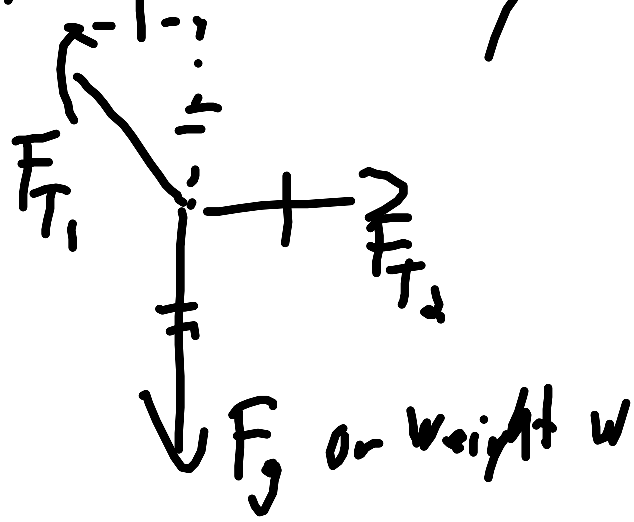
$F_{net} = F_N - F_g$ $\quad F_g = mg$

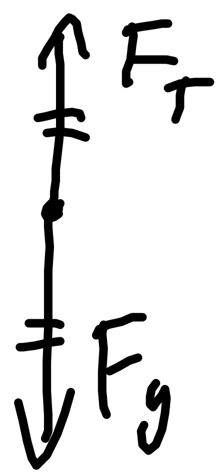
$F_N = F_{net} + F_g = 3500N + 500N$

$= \boxed{4.0 \times 10^3 N}$

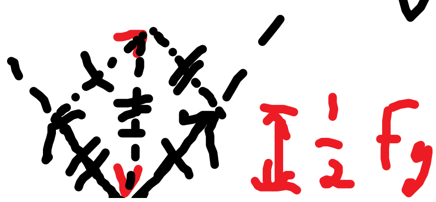
Q3 $\boxed{60.7kg}$

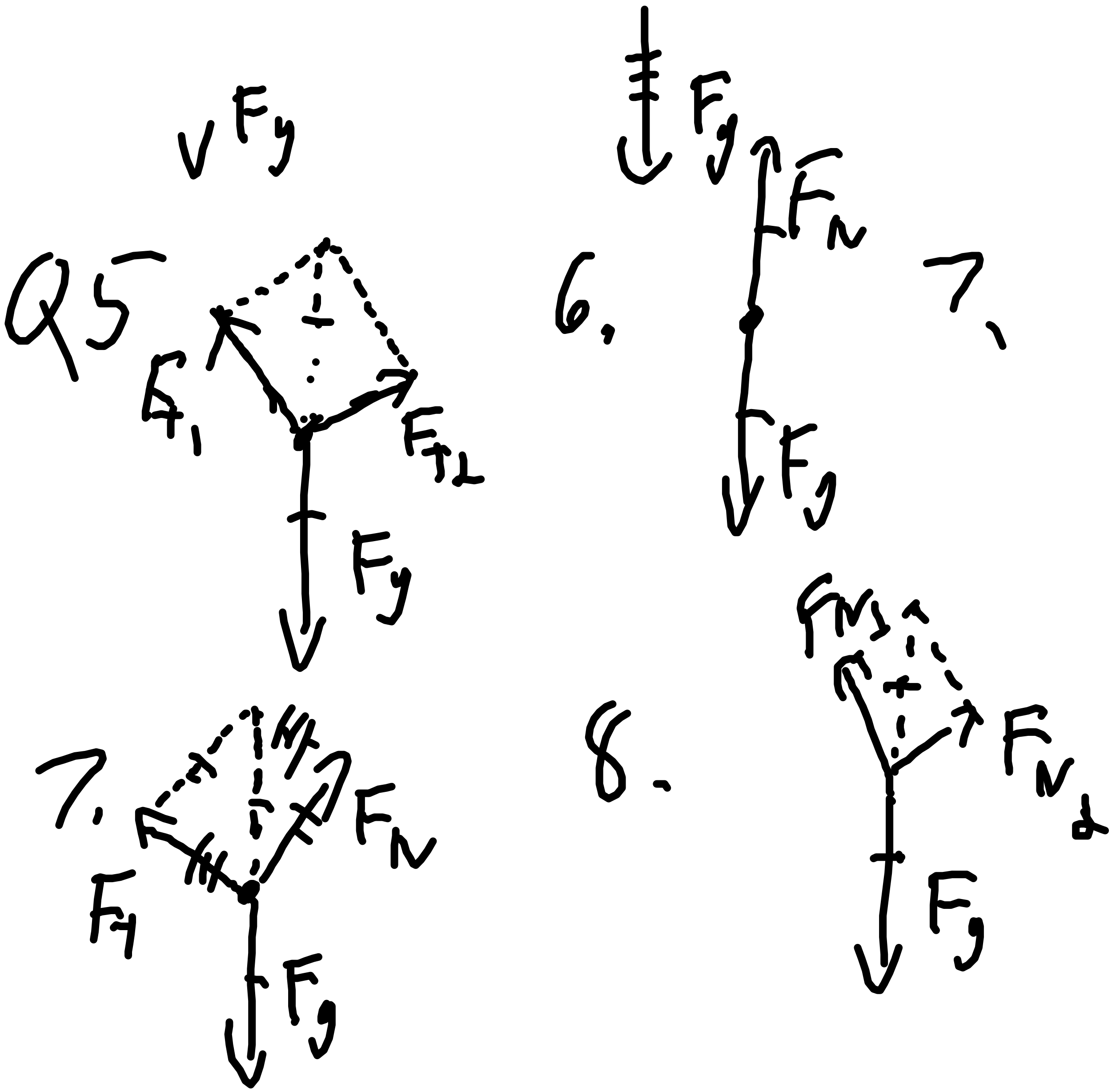
Free body Diagram

1. 

2. 

3

4 



Friction and Slopes

Types of forces:
Tension Force, F_t in a string or rope or cable. At each end.
Force of gravity, F_g or weight, W.
gravitational field strength, g

$F_g=mg$
eg. a 10 kg mass is on Earth, what is F_g? g?
$F_g = 98N$ $g=9.80N/kg$

Normal force, F_N is the perpendicular component of the force of the surface on an object.
Surface force, F_s is the vector sum of the normal force and the frictional force.
Friction force, F_f is force opposing sliding motion - parallel to the surface.
The frictional force is proportional to the magnitude of the normal force. The constant of proportionality, μ, depends on the type of surfaces. Static friction - no sliding, static μ_s. Kinetic is when the surfaces are sliding past (assume it doesn't really depend of speed), μ_k.
static is usually greater than kinetic
$F_f=\mu F_N$

eg. You lift a wooden block with a force

scale and it reads 3.0N. You pull the block sideways on the table and it just starts to move when the applied force is 1.20N and then it moves at a constant speed with 1.00N.

a) what is the mass of the block

b) determine the coefficient of friction
  - static and kinetic

c) If I pulled the block with 1.50N of force, what is the acceleration?

d) draw free body diagrams for
  i) questions c)
  ii) put a frictionless cart on a slope, angle θ to the horizontal
  iii) put the block on the slope with enough friction so it is stationary.
  iv) the block is moving up the slope
  v) the block is sliding down the slope

a) $m = \frac{F_g}{g} = \frac{3.0\,N}{9.8\,N/kg} = \boxed{0.31\,kg}$

b) $\mu_s = \frac{F_f}{F_N} = \frac{1.2\,N}{3.0\,N} = \boxed{0.40}$

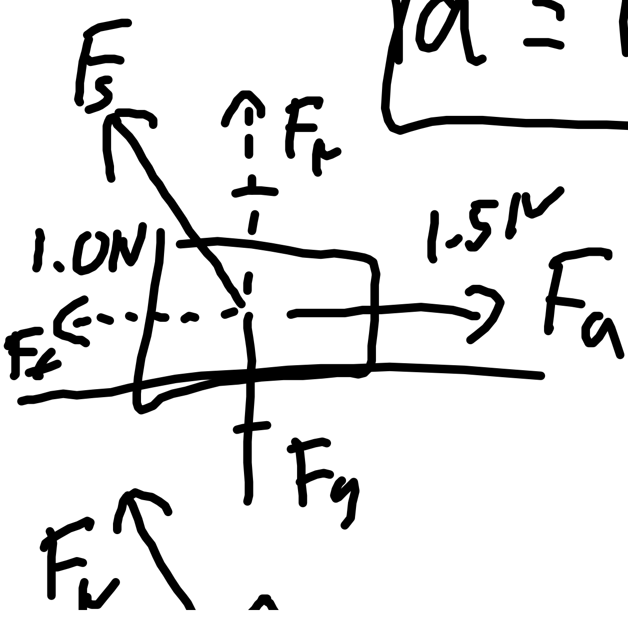
$\mu_K = \boxed{0.33}$

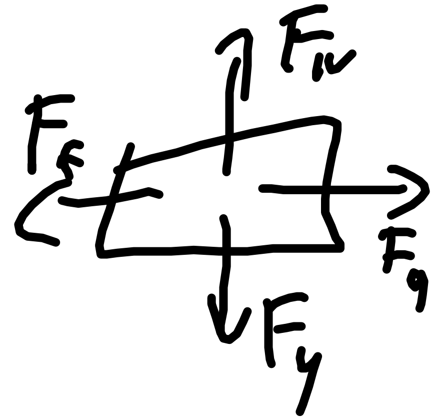
d) $F_{net} = F_a - F_f = 1.5\,N - 1.0\,N$

$F_{net} = 0.50\,N = 0.31\,kg\ a$

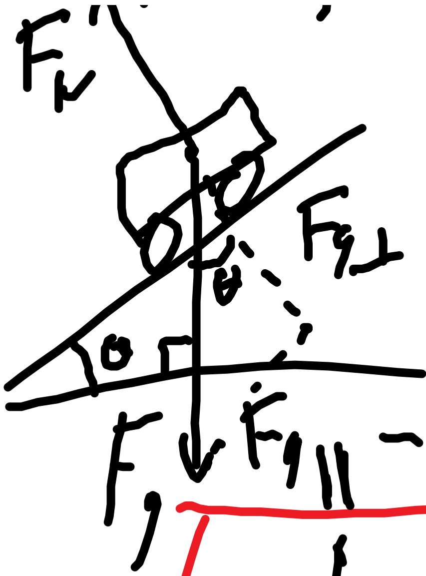
$\boxed{a = 1.6\,m/s^2}$

e) i)





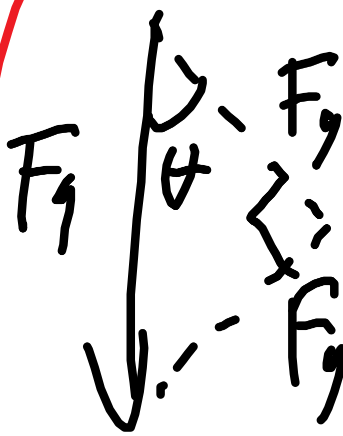
i)



book

$F_{g\perp}$ Perpendicular to surface

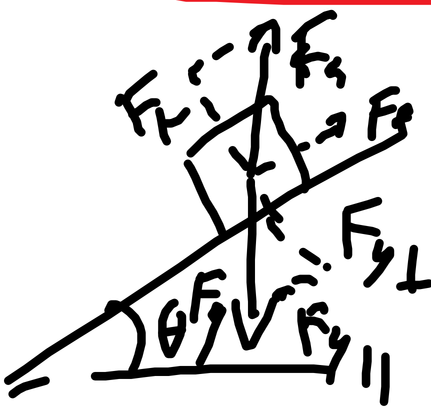
$F_{g\parallel}$ - Parallel - to surface



$$F_{g\perp} = F_g \cos\theta$$

$$F_{g\parallel} = F_g \sin\theta$$

ii)



$$F_N = F_{g\perp} = F_g \cos\theta$$

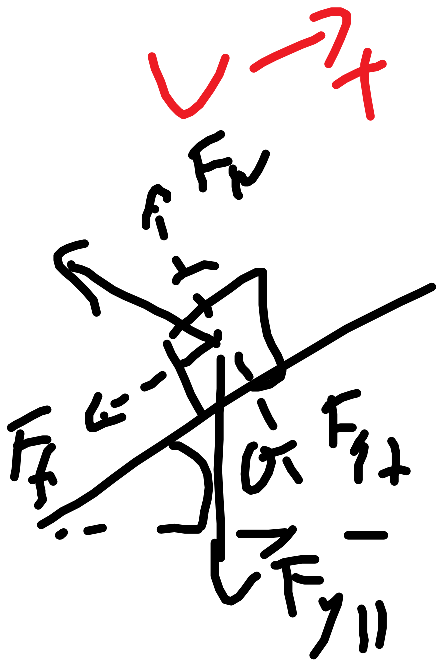
$$F_f = F_{g\parallel} \quad \text{Static}$$

$$\mu F_N = F_g \sin\theta$$

$$\mu \cancel{F_g} \cos\theta = \cancel{F_g} \sin\theta$$

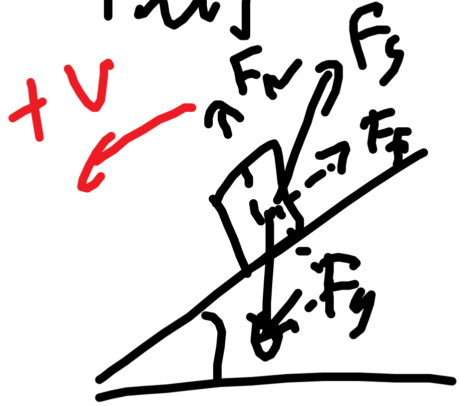
$$\mu = \frac{\sin\theta}{\cos\theta}$$

$$\boxed{\mu = \tan\theta}$$ static



$$F_{net} = -(F_{g\parallel} + F_f)$$

$$F_{net} = -(F_g \sin\theta + \mu F_g \cos\theta)$$



$$F_{net} = F_{g\parallel} - F_f$$

$$F_{net} = F_g \sin\theta - \mu F_g \cos\theta$$

Monday, November 02, 2015
8:44 AM

Block on a slope lab

procedure:

1. get 3 blocks with different surfaces. 1 or 2 spring scales - 1 up to 5N 1 up to 2.5N if you can find it. Metre stick or protractor and a wooden ramp.
2. pull the blocks on the ramp sideways and determine the static friction and kinetic friction for each surface. Lift the block to get the weight. calculate the coefficient of friction for each surface.
3. lift the ramp until the block just slides. record the angle for each surface. compare using the equation $\mu=\tan\theta$
4. put the ramp to a smaller angle, pull each block up and down the ramp. compare to the equation $Fa = \mu F_g \cos\theta \pm F_g \sin\theta$
5. return to class and work on p94-96 33-51odds - note 49 and 51 will be on quiz
6. go over last class assignment

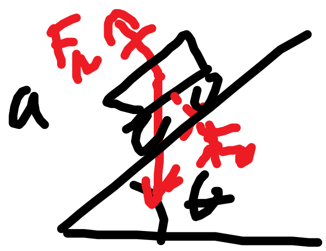
eg. you lift a block and it is 3.0 N pull it and it requires 1.8N to pull sideways, 1.5N at constant velocity.

$\mu = F_f/F_N = 1.8N/3.0N = 1.8/3 = 0.60$

you lift the ramp until $\theta = \tan^{-1}(0.60)$
31º

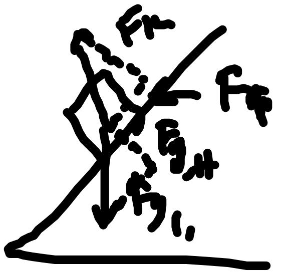
eg. the 3.0N block is now placed on a 25.0º to the horizontal slope. What is the acceleration of the block if

a) the surface is frictionless



$a = g\sin\theta$
$= 3.35\ m/s^2$

b) the coefficient of kinetic friction is 0.20 and block is sliding down



$F_N = F_{g\perp}$

$F_{net} = F_g \sin\theta - \mu F_g \cos\theta$

$a = g(\sin\theta - \mu g\cos\theta)$

$a = g(\sin\theta - \mu g \cos\theta)$

$a = 9.8(\sin 25 - 0.2\cos 25) = \boxed{2.37 m/s^2}$

c) the same coefficient but the block is sliding up

$a = 9.8(\sin 25 + 0.2\cos 25) =$

$= 5.92 m/s^2$

d) what is the maximum angle of slope the block can sit on without sliding if the static coefficient is 0.30?

$\theta = \tan^{-1}(0.30) = 16.7^{\circ}$

e) How long will it take for the block in c to slide up and slide back to the same point if you give it an initial speed of 2.0 m/s?

up $a = -5.92 m/s^2$ down $a = 2.37 m/s^2$

$V_f^2 = V_i^2 + 2ad$

$$0 = 2.0\,m/s^2 + 2(-5.92)d$$

$$d = 0.338\,m$$

$t_{up} = ?$ $\quad V_f = at + V_i$

$$t = \frac{2}{5.92} = \boxed{0.338\,s}$$

$t_{down} = ?$

$$d = \frac{1}{2}at^2 + V_i t$$

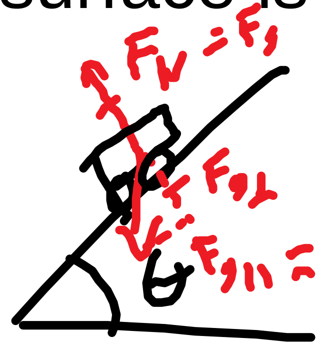
$$0.338\,m = \frac{1}{2}\left(2.37\,m/s^2\right)t^2 + \cancel{V_i t}^{\,0}$$

$$t_{down} = \sqrt{\frac{2(0.338)}{2.37}} = 0.534\,s$$

$$t_{total} = t_{up} + t_{down} = \begin{array}{r} 0.338\,s + \\ 0.534\,s \\ \hline \boxed{0.87\,s} \end{array}$$

eg. the 3.0N block is now placed on a 25.0º to the horizontal slope. What is the acceleration of the block if

a) the surface is frictionless



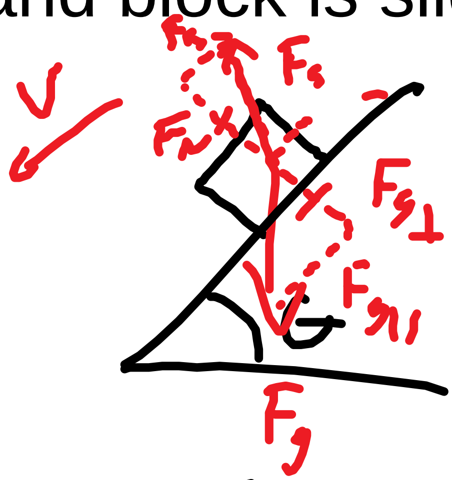
$a = g\sin\theta$

$a = 9.8\,m/s^2 \sin 25°$

$= 4.1417\,m/s^2$

$\boxed{a = 4.14\,m/s^2}$

b) the coefficient of kinetic friction is 0.20 and block is sliding down



$F_{net} = F_{g\parallel} - F_f$

$\cancel{m}a = \cancel{m}g\sin\theta - \mu \cancel{m}g\cos\theta$

$a = g(\sin\theta - \mu g\cos\theta)$

$a = 9.8\,m/s^2(\sin 25° - 0.2\cos 25°) = 2.3752$

$= \boxed{2.4\,m/s^2}$

c) the same coefficient but the block is sliding up

$v \rightarrow$ $F_{net} = -(F_{\parallel} + F_f)$

sliding up

$F_{net} = -(F_{g\parallel} + F_f)$

$ma = -(mg\sin\theta + \mu mg\cos\theta)$

$a = -g(\sin\theta + \mu\cos\theta)$

$a = 9.8\,m/s^2(\sin 25^\circ + 0.2\cos 25^\circ)$

$a = -5.9180\,m/s^2 = \boxed{-5.9\,m/s^2}$

d) what is the maximum angle of slope the block can sit on without sliding if the static coefficient is 0.30?

$\mu_s = \tan\theta$

$\theta = \tan^{-1}(0.30) = \boxed{17^\circ}$

e) How long will it take for the block in c to slide up and slide back to the same point if you give it an initial speed of 2.0 m/s?

$V_i = 2.0\,m/s \quad V_f = 0$

up. $d = ?$ $t = ?$ $V_i = 2.0 \, m/s$ $V_f = 0$

$a = -5.918 \, m/s^2$

$V_f = at + V_i$ $t = \frac{V_f - V_i}{a} =$

$t_{up} = \frac{0 - 2.0 \, m/s}{-5.918 \, m/s^2} = \boxed{0.338 \, s}$

$d = \frac{V_f^2 - V_i^2}{2a} = \frac{0 - 4}{2(5.918)} = \boxed{0.338 \, m}$

$d = \frac{1}{2}(-5.918)(0.338)^2 + 2(0.338)$

$d = \frac{1}{2} a t^2$

$d_{down} = 2.3652$

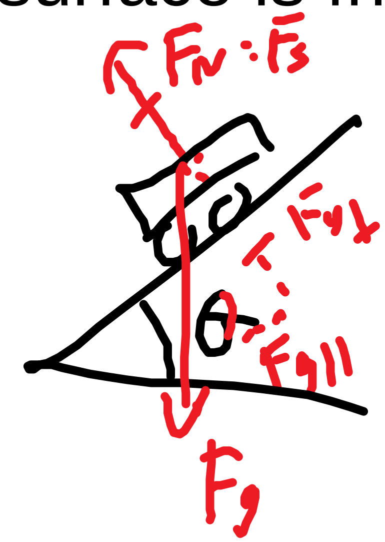
$t_d = \sqrt{\frac{2(0.338 \, m)}{2.3652}} = 0.534 \, s$

$t = t_{up} + t_d = \boxed{0.873 \, s}$

$$t = t_{up} + t_{d} = \boxed{0.873\,s}$$

eg. the 3.0N block is now placed on a 25.0º to the horizontal slope. What is the acceleration of the block if

a) the surface is frictionless



$$F_{net} = F_{g\parallel}$$

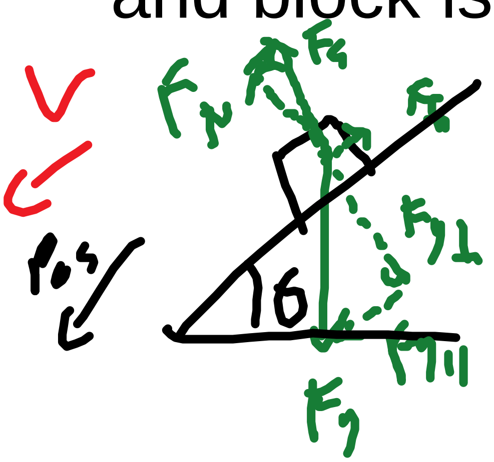
$$\cancel{m}a = \cancel{m}g\sin\theta$$

$$a = 9.80\,m/s^2 \sin 25.0^\circ$$

$$a = 4.142\,m/s^2$$

$$\boxed{4.14\,m/s^2}$$

b) the coefficient of kinetic friction is 0.20 and block is sliding down



$$F_{net} = F_{g\parallel} - F_f$$

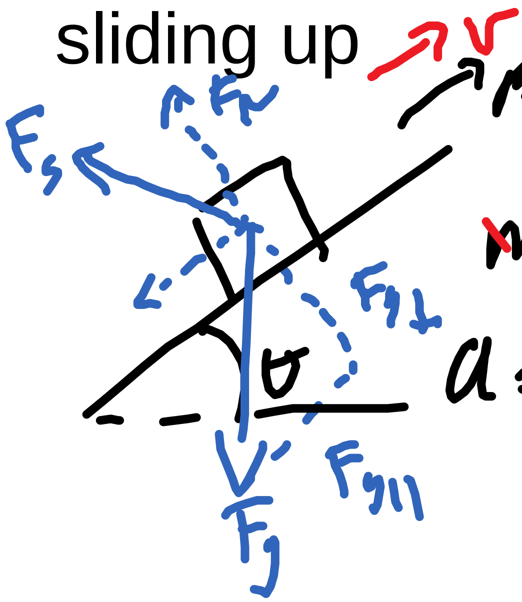
$$\cancel{m}a = \cancel{m}g\sin\theta - \mu\cancel{m}g\cos\theta$$

$$a = 9.80\,m/s^2(\sin 25^\circ - 0.2\cos 25^\circ)$$

$$a = 2.3653 = \boxed{2.4\,m/s^2}$$

$$a = 2.3653 = \boxed{2.4\ m/s^2}$$

a) the same coefficient but the block is sliding up



$$F_{net} = -(F_{g\parallel} \pm F_f)$$

$$\cancel{m}a = -(\cancel{m}g\sin\theta + \mu \cancel{m}g\cos\theta)$$

$$a = -9.80\ m/s^2\,(\sin 25 + 0.2\cos 25)$$

$$= -5.918 = \boxed{-5.9\ m/s^2}$$

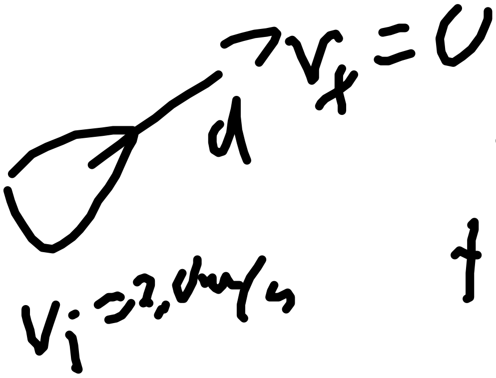
a) what is the maximum angle of slope the block can sit on without sliding if the static coefficient is 0.30?

$$\cancel{F_g}\sin\theta = \mu\cancel{F_g}\cos\theta \rightarrow \mu = \frac{\sin\theta}{\cos\theta}$$

$$\mu = \tan\theta$$

$$\theta = \tan^{-1} 0.30 = 16.7^\circ = \boxed{17^\circ}$$

a) How long will it take for the block in c to slide up and slide back to the same point if you give it an initial speed of 2.0 m/s?



$a = -5.918\, m/s^2$

$t = ?$ $\quad v_f = at + v_i$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 2\,m/s}{-5.918}$$

$t_{up} = 0.338\,s$

$d = ?$ $\quad v_f^2 = v_i^2 + 2ad$

$$d = \frac{0 - (2.\,m/s)^2}{2(-5.918\,m/s^2)} = \underline{0.338\,m}$$

$t_d = ?$ $\quad a = 2.36\,m/s^2 \quad v_i = 0$

$$d = \frac{1}{2} a t^2 + \cancel{v_i t}^{\,0}$$

$$t_d = \sqrt{\frac{2(0.338\,m)}{2.36\,m/s^2}} = 0.532\,s$$

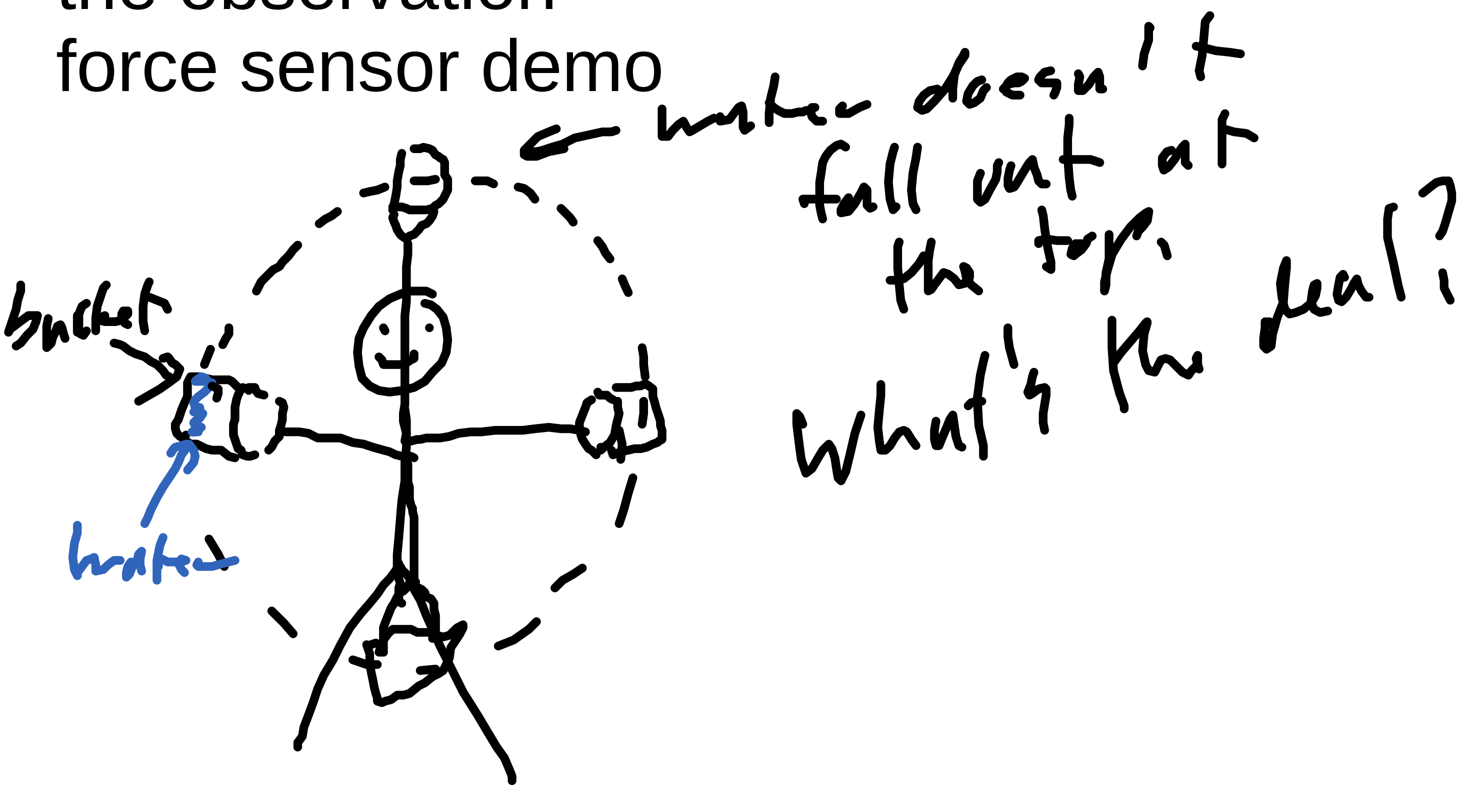
$$t = t_{up} + t_{down} = 0.338 + 0.532 = \boxed{0.87\,s}$$

$= \boxed{0.875}$

Friday, November 06, 2015
8:43 AM

Block 1-1

Circular Motion - (Chapter 5)
Holding a buck of water over my head.
deriving an equation explaining the observation
force sensor demo



Define circular motion: motion in a circle
uniform circular motion: constant speed (not constant velocity because the direction is constantly changing)
non -uniform circular motion: circular path but the speed changes.

bucket demo could be done at a constant speed or not

In both cases, the velocity is changing, therefore there is acceleration therefore there is a net-force.

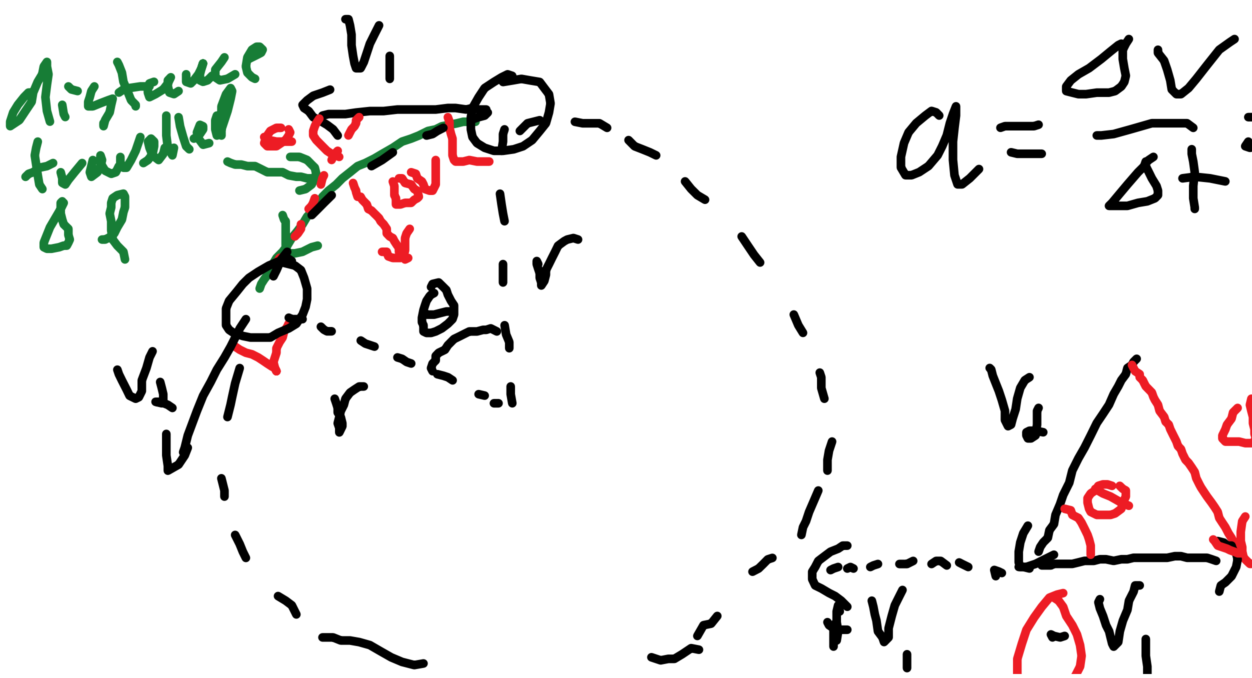
Define the centripetal force, F_C, as the component of the net force towards the centre of the circle.

Define the centripetal acceleration, a_c, as the component of the acceleration towards the centre of the circle.

Lets quantify it by looking at uniform circular motion with an object moving at speed v in a circle radius r. The velocity at 2 times are v_1 and v_2.

Vector

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t}$$

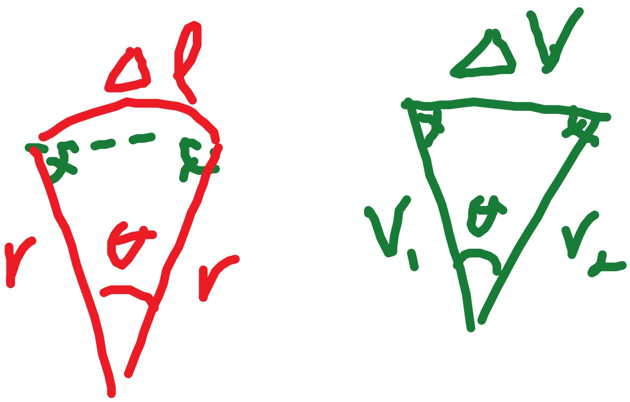


$\Delta v = v_2 - v_1$

$-V_1$ $\ominus V_1$

subtraction

Note the direction of the acceleration is towards the centre of the circle for uniform circular motion. $a_c = a$ $F_c = F_{net}$



similar Δs

$$\frac{\Delta l}{r} = \frac{\Delta v}{v} \qquad \Delta v = \frac{\Delta l\, v}{r}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{\Delta l}{\Delta t}\frac{v}{r}$$

speed, v

$$\boxed{a = \frac{v^2}{r}}$$

uniform circular motion

for non-uniform $\boxed{a_c = \frac{v^2}{r}}$

$F_{net} = ma = \frac{mv^2}{r}$ for uniform

$\boxed{F_c = \frac{mv^2}{r}}$ non-uniform

The centripetal force is not a force, it is a specific case and component of the net force. It is the sum of all forces, not a force.

Next demo: a student(Roy) will hold a force sensor and move a 500g mass

1. horizontally in a circle radius 0.82m
2. vertically in a circle radius 0.82m

If Roy spins the mass so that it takes

0.75s to do a revolution.

What will the speed of the mass be?

v=d/t = 2πr/T

What will the force sensor read for

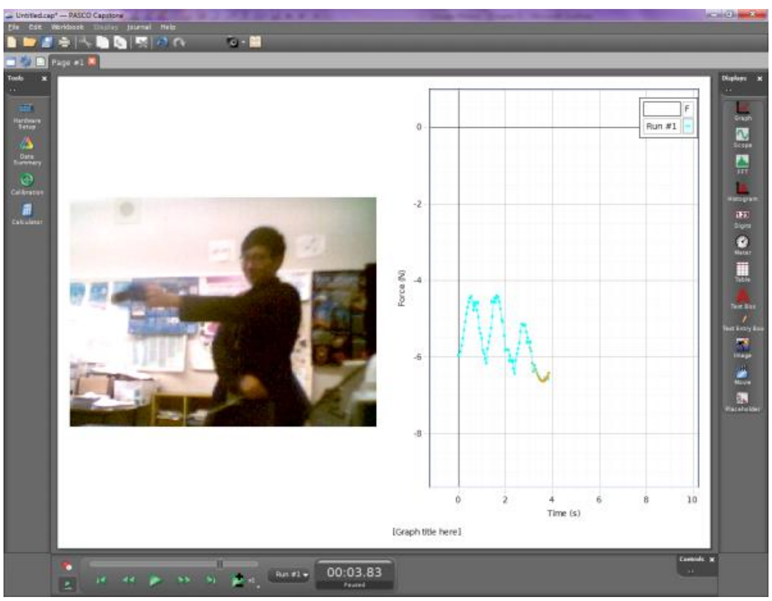
a) horizontal motion?

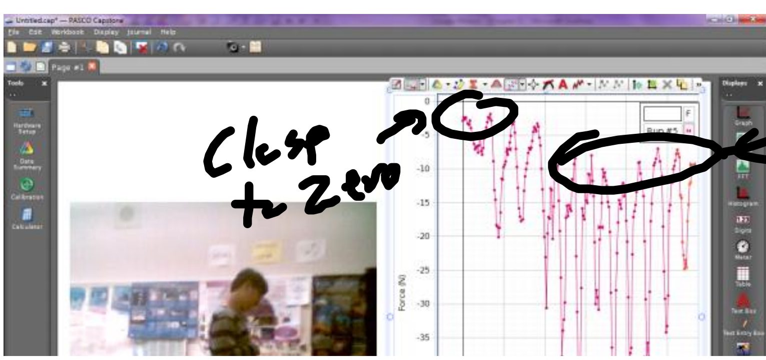
b) vertical motion at i) top ii) side iii) bottom?

finish the free body diagram worksheet

p119 Q1,3,5

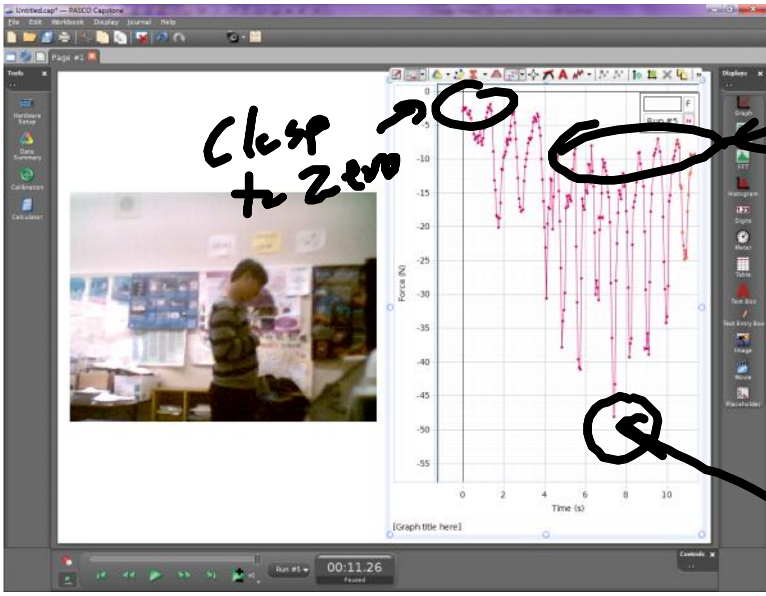
p120 problems 1,3,5 (Tues q 7-15 odds)





close to zero

mass is at top F~10N



close to zero

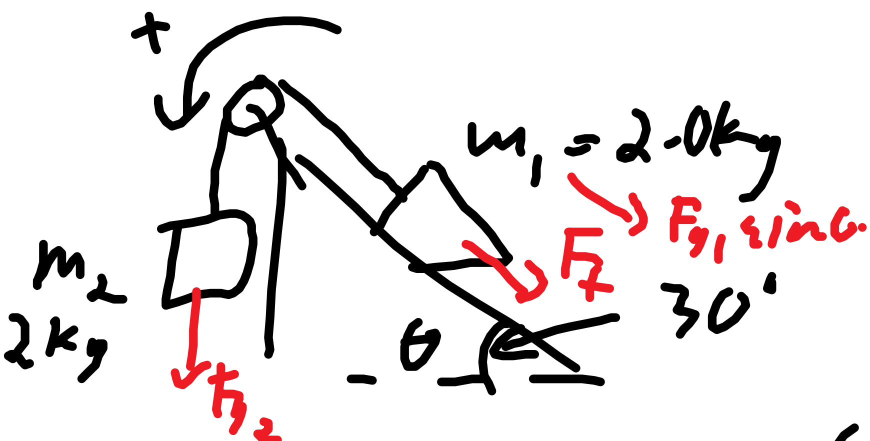
mass is at top $F \sim 10N$

mass is at the bottom

F up to 48N

$0.5k = 4.9N$

Block 1-2



$$a = 0 = F_{net} = F_{g_2} - (F_{g_1}\sin\theta + F_f)$$

$$\cancel{F_{...}}\; 0 = m_2 g - (m_1 g \sin\theta + \mu m_1 g \cos\theta)$$

$$m_2 g - m_1 g \sin\theta = \mu m_1 g \cos\theta$$

$$\mu = \frac{\cancel{m_2} \cancel{g} - \cancel{m_1} \cancel{g} \sin\theta}{\cancel{m_1} \cancel{g} \cos\theta}$$

$$\mu = \frac{1 - \sin\theta}{\cos\theta} = \frac{1 - \sin 30}{\cos 30}$$

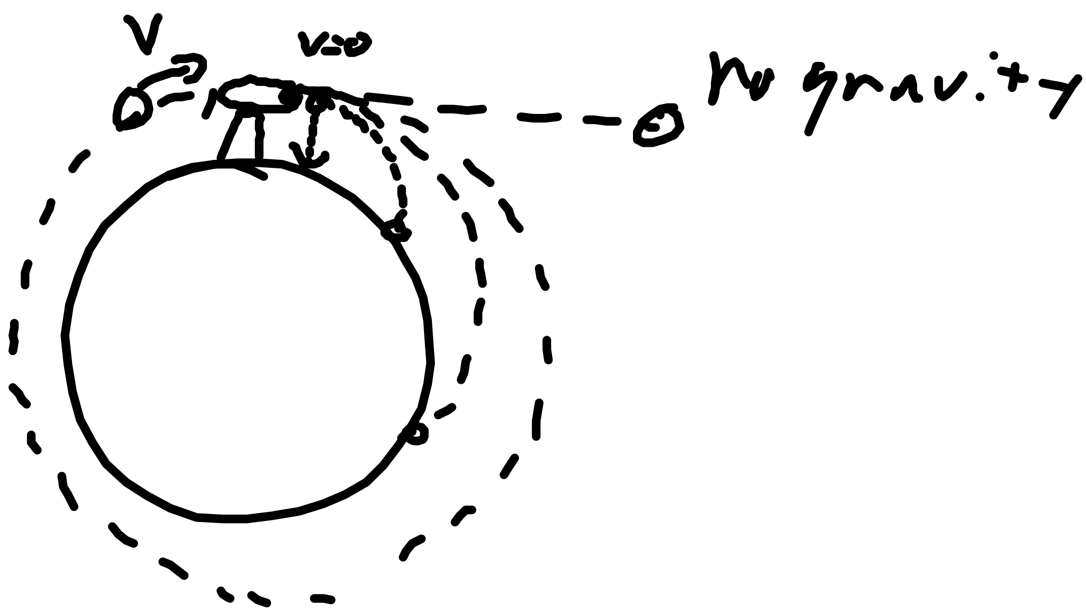
$$\mu = 0.577 = \boxed{0.58}$$

Circular Motion (Chapter 5)
Motion in a circular path.
uniform circular motion: constant speed
*NOTE - not constant velocity as the direction is constantly changing
if the velocity is constantly changing, it must be accelerating.

Look at a bucket of water: I rotate it over my head but the water doesn't fall out. What's the deal? (avoid centrifugal)

The inertia of the water keeps it going. If there was no net force, it would move in a straight line. gravity causes the water to fall a bit but it is moving fast enough to stay in a circular path.

- why doesn't the moon fall on our heads or why don't we fall into the sun? Because we are moving fast enough that as we fall, we miss.

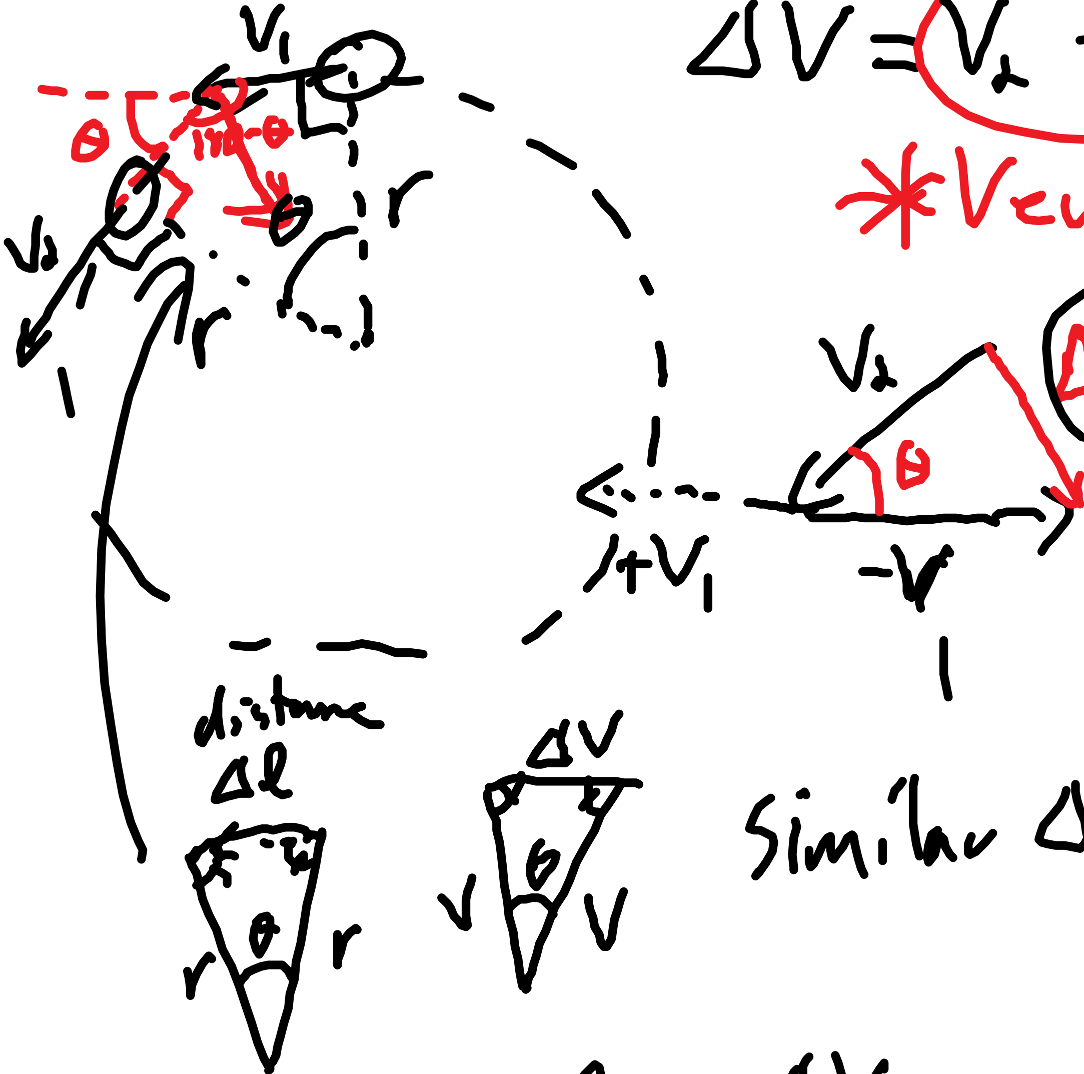


Look at an object moving at speed v in a

circular path radius r. To find acceleration, $a=\Delta v/\Delta t$ so we will look at the velocity at two points, v_1 and v_2. If this is uniform circular motion, the magnitudes will be the same.

$\Delta V = V_2 - V_1$

*Vectors



Similar Δs

Sides in proportion

$$\frac{\Delta l}{r} = \frac{\Delta V}{V} \qquad \Delta V = \frac{V\Delta l}{r}$$

ΔV $V\Delta l$

$$a = \frac{\Delta v}{\Delta t} = \frac{v\,\Delta l}{r\,\Delta t}$$

← speed v

$$\boxed{a = \frac{v^2}{r}}$$

Uniform circular motion

towards the centre of the circle.

For non-uniform circular motion, the above equation applies to the component of the acceleration towards the centre of the circle - centripetal acceleration, a_c.

$$a_c = v^2/r$$

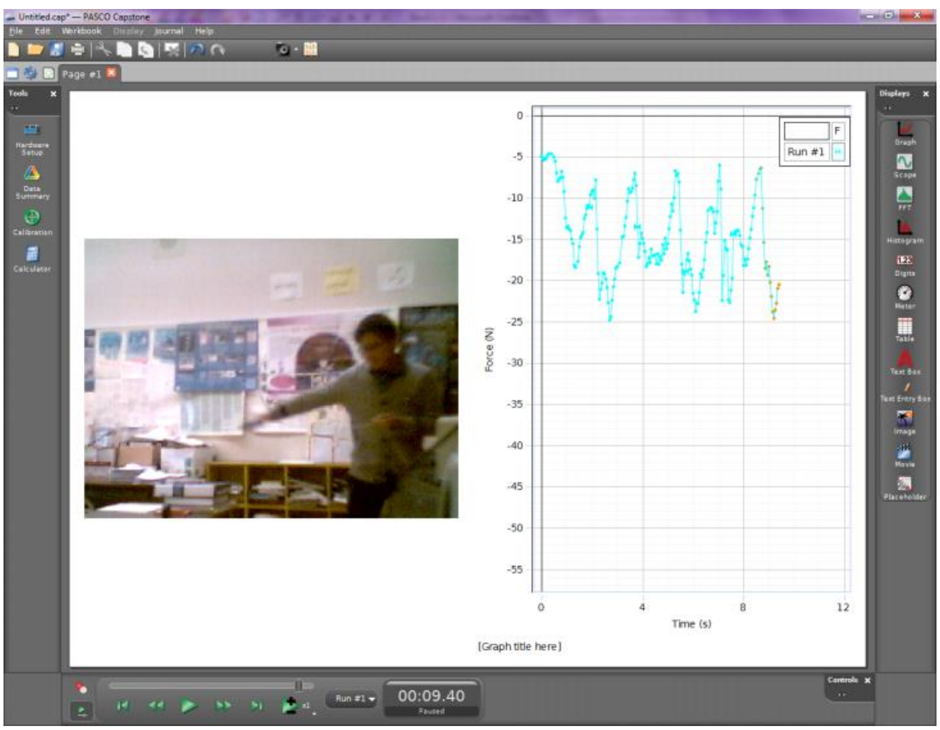
In general $F_{net}=ma$
for uniform circular motion

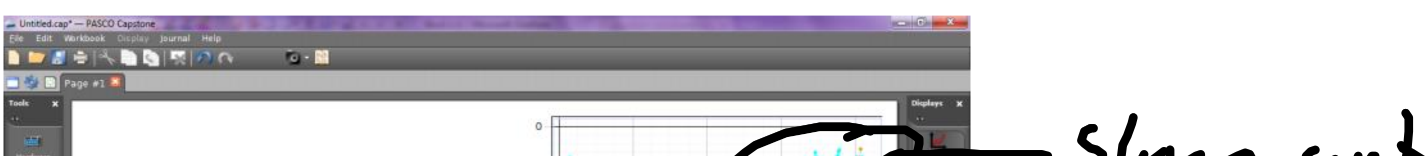
$F_{net}=mv^2/r$

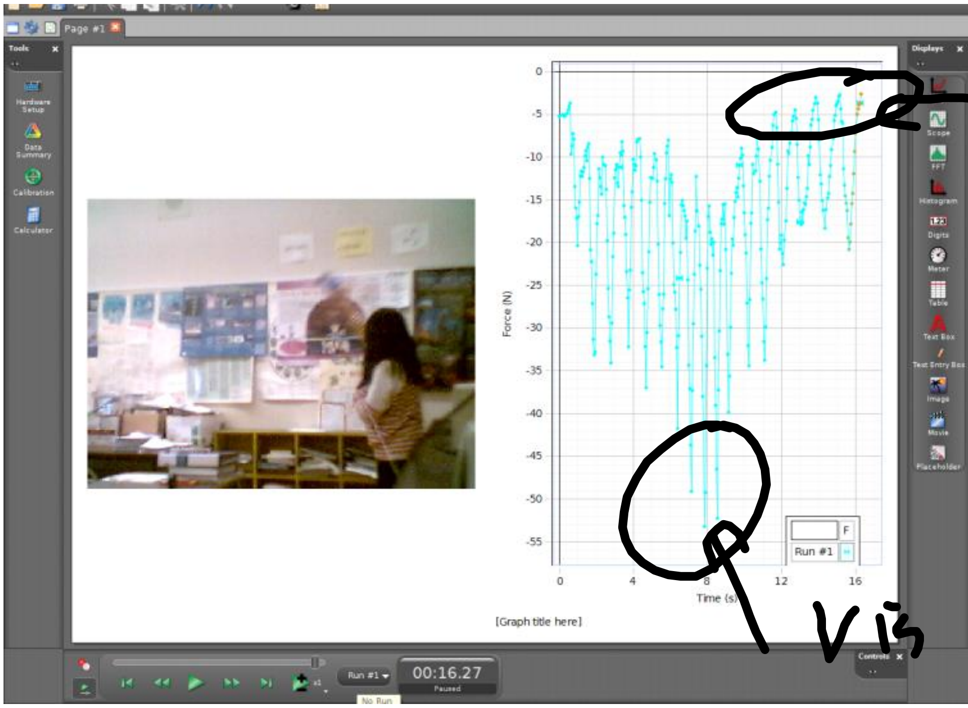
for non-uniform circular motion F_c is the component of the net force towards the centre of the circle.

$$F_c=mv^2/r$$

Note: centripetal force is not a force - it is a component of the net force, the vector sum of all forces.







slow out at the top.

v is fast + bottom

Next demo: a student(X) will hold a force sensor and move a 500g mass

1. horizontally in a circle radius 0.82m
2. vertically in a circle radius 0.82m

If X spins the mass so that it takes 0.75s to do a revolution.

What will the speed of the mass be?

$v = d/t = 2\pi r/T$ T is period

What will the force sensor read for

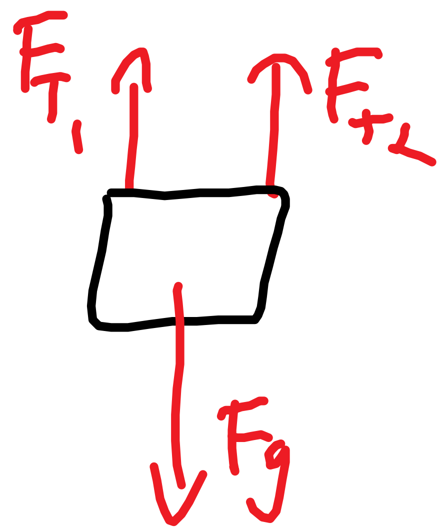
a) horizontal motion?

b) vertical motion at i) top ii) side iii) bottom?

finish the free body diagram worksheet
p119 Q1,3,5
p120 problems 1,3,5 (Tues q 7-15 odds)

Block 1-3
Homework questions?
Circular Motion - (Chapter 5)
Holding a buck of water over my head.
Deriving an equation explaining the observation.
Force sensor demo

p 94
Q 27



$F_{net} = \Sigma F = F_{T_1} + F_{T_2} - F_g$

a) $F_T = F_g$

a) $F_T = \frac{1}{2} F_g$

increase by 10%

b) $F_T = 1.1\left(\frac{1}{2} F_g\right)$

$F_{net} = F_{T_1} + F_{T_2} - F_g$

$= 1.1\left(\frac{1}{2}F_g\right) + 1.1\left(\frac{1}{2}F_g\right) - F_g$

$= \boxed{0.1\, F_g}$

$0.1\cancel{m}g = \cancel{m}a$

$a = 0.1 \times 9.8$

$\boxed{a = 0.98\ m/s^2}$

Circular Motion (chapter 5)

definition: motion in a circle

uniform circular motion: constant speed

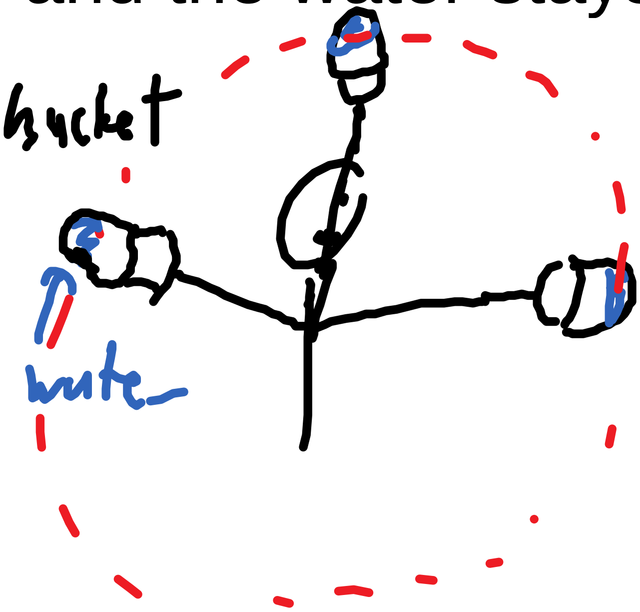
note: the velocity cannot be constant if the motion is circular - the direction changes.

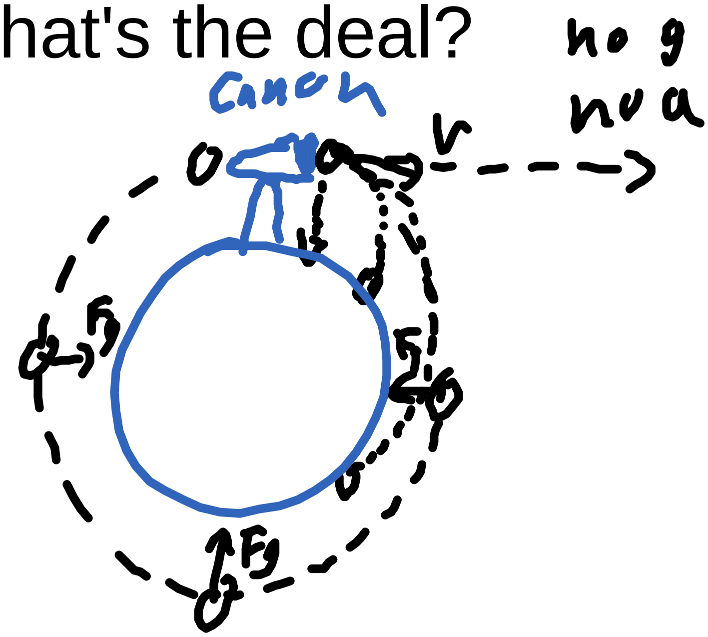
Therefore, there must be acceleration.

$a = \Delta v / \Delta t$

Demo:

swing a bucket of water over your head and the water stays. What's the deal?





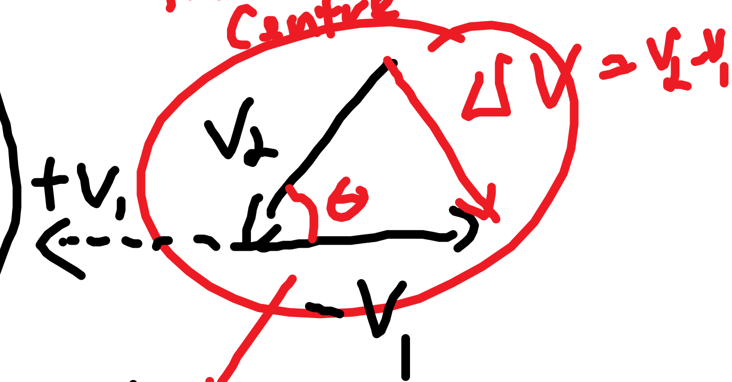
The inertia of the bucket would keep it moving in a straight line. Gravity and the force of your hand on the bucket (tension) deflect the path into circular motion. So the moon is moving fast enough sideways that as it falls it moves in a circular path, rather than straight down.

Look at an object moving at speed v, in a circular path radius r. The velocity at 2 times are v_1 and v_2. derive and equation for acceleration

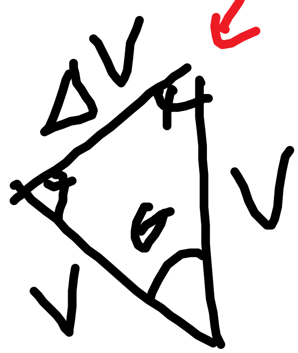
Vectors

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t}$$

towards Centre



distance travelled



Similar Δs

Sides in proportion

$$\frac{\Delta l}{r} = \frac{\Delta v}{v} \qquad \Delta v = \frac{\Delta l\, v}{r}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{\Delta l\, v}{\Delta t\, r} =$$

speed, v

$$\boxed{a = \frac{v^2}{r}}$$ ← uniform circular motion
- towards centre

$$\boxed{F_{net} = ma = \frac{mv^2}{r}}$$

What if the speed is not constant?
I will not do the derivation, so just trust me.
define centripetal acceleration, a_c, is the component of the acceleration towards the centre of the circular motion.
define centripetal force, F_c, is the component of the net force towards teh centre of the circular motion.
- don't put F_c on your free body diagram, it is the resultant of your vector addition

diagram.

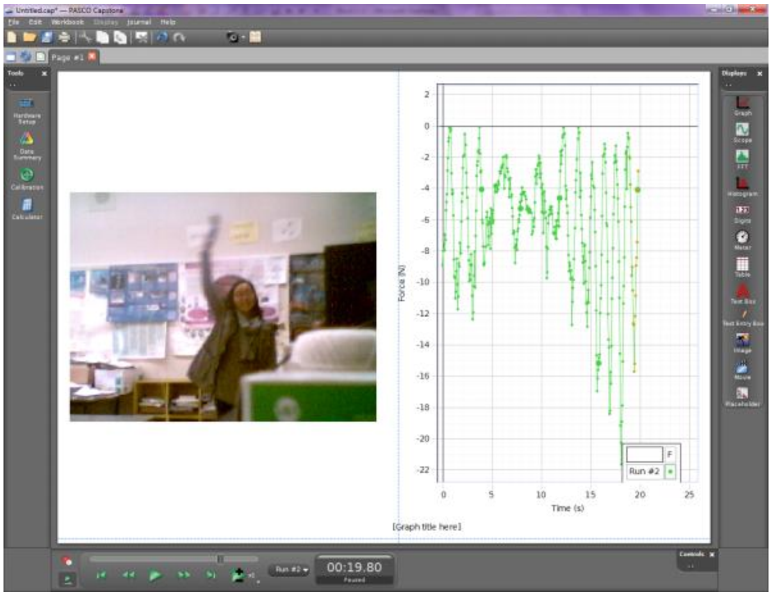
$$\boxed{F_c = ma_c = mv^2/r}$$

where v is the instantaneous speed

eg. Emily swings a 500g mass in a 0.73m radius circle in 1.5s. What is the tension in the force sensor when she swings (remember $v=d/t= 2\pi r/T$ where T is period)

a) horizontally
b) vertically at the top
c) vertically at the side
d) vertically at the bottom

p119 Q1,3,5, and 120 Prob.1,3,5
finish the free body diagrams worksheet



Tuesday, November 10, 2015
8:52 AM

Next demo: a student will hold a force sensor and move a 500g mass

1. horizontally in a circle radius 0.82m
2. vertically in a circle radius 0.82m

If the student moves the mass so that it takes 0.75s to do a revolution.

What will the speed of the mass be?

$v = d/t = 2\pi r/T = 2\pi(0.82\text{m})/0.75\text{s}$

$v = 6.87\text{m/s} = 6.9\text{m/s}$

What will the force sensor read for

a) horizontal motion?

$Ft = Fc = mv^2/r = m4\pi^2 r/T^2$

$= (0.50\text{kg})\, 4\pi^2(0.82\text{m})/(0.75\text{s})^2 \quad = \frac{mv^2}{r}$

$= 28.778\text{N} = 29\text{N}$

b) vertical motion at i) top ii) side iii) bottom?

i)top

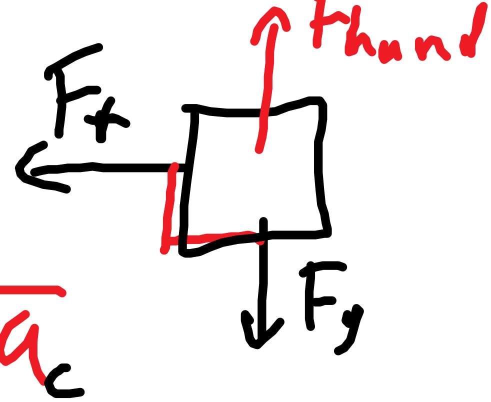
$\downarrow a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$

$$F_g + F_t = \frac{mv^2}{r} = \frac{m4\pi^2 r}{T^2}$$

$$4.9N + F_t = 28.778N$$

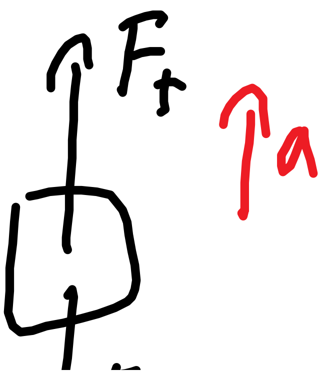
$$\boxed{F_t = 24N}$$

ii) Side $F_t = ?$



$$F_{net} = ma = F_t = \frac{mv^2}{r} = \frac{m4\pi^2 r}{T^2}$$

$$\boxed{F_t = 29N}$$



$$F_{net} = ma = F_t - F_g$$

$$F_t = ma + F_g$$

$$F_t = \frac{mv^2}{r} + F_g$$

$$F_t = 28.778\,N + 4.9\,N$$

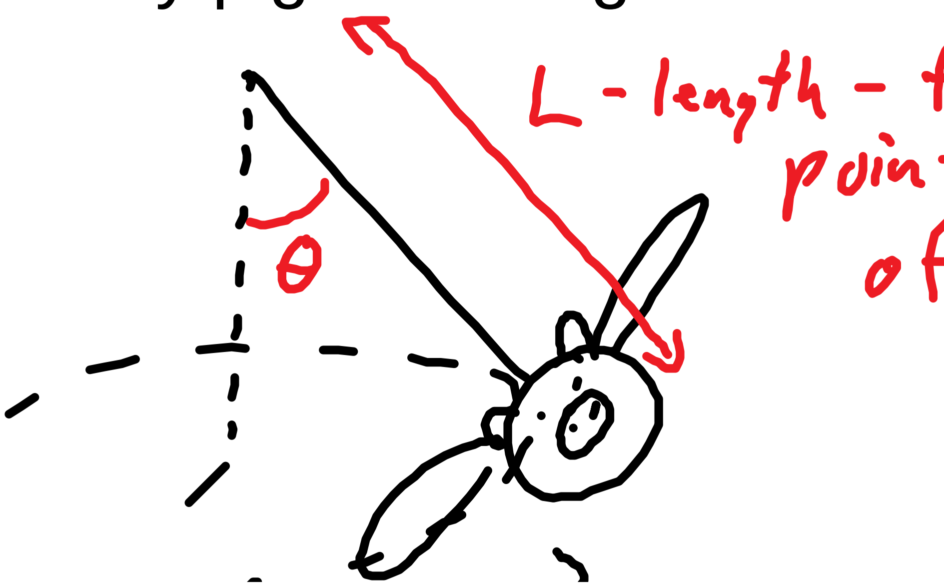
$$= \boxed{34\,N}$$

Lab - Flying Pig (not in lab manual but it is related to p51 to 55)

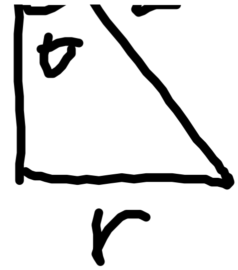
Purpose: Look at factors that influence the period of revolution of a toy on a string moving in circular motion.

Hypothesis:

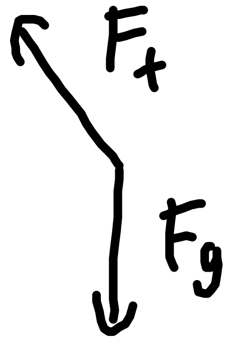
Toy pig with wings on a string:



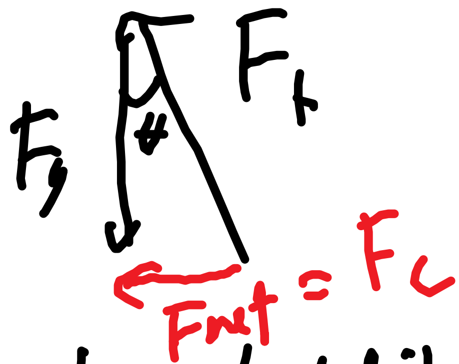
$\sin\theta = \frac{r}{L}$



$\sin\theta = \frac{\;}{L}$



free body diagram



Vector Addition

$$\tan\theta = \frac{F_c}{F_g}$$

for small θ

$$\sin\theta \sim \tan\theta$$

$$\frac{\cancel{r}}{L} = \frac{F_c}{F_g} = \frac{\cancel{m}\,4\pi^2 \cancel{r}}{\cancel{m}\,g\,T^2}$$

$$\frac{r}{\;} = \frac{m\,4\pi^2 r}{T^2}$$

$$L \qquad \overline{mgT^2}$$

$$mgT^2 r = m4\pi^2 r L$$

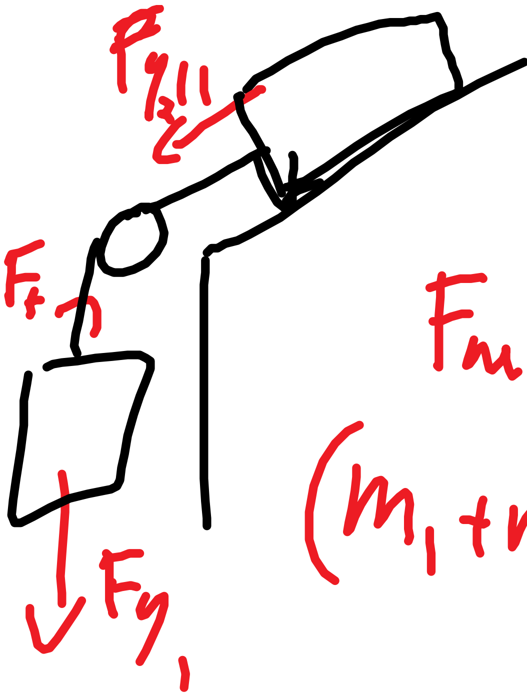
$$T^2 = \frac{\cancel{m}4\pi^2\cancel{r}L}{\cancel{m}g\cancel{r}}$$

$$\boxed{T^2 = \frac{4\pi^2}{g} L} \ast$$

graph T^2 vs L slope $= \frac{4\pi^2}{g}$ theory

p120 Problems 7-15 odds

15b killer



$F_{net} = F_{g_1} + F_{g_2 \parallel}$

$(m_1 + m_2) a = m_1 g + m_2 g \sin\theta$

b) $- \mu m_2 g \cos\theta$

$F_t - F_{g_1} = m_1 a$

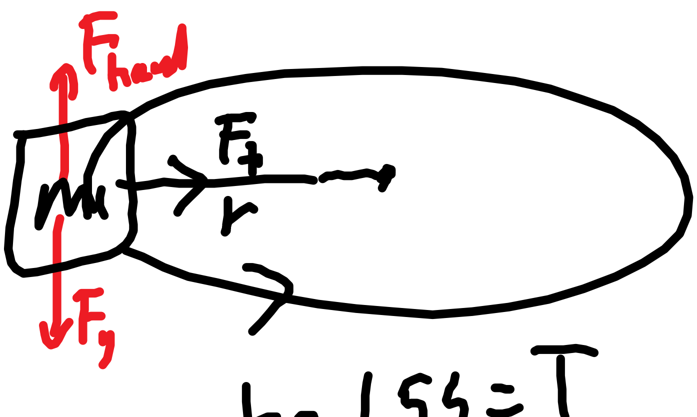
$a = \frac{v^2}{r}$ $\quad V = \frac{2\pi r}{T}$

$a = \left(\frac{2\pi r}{T}\right)^2 / r$

$$a = \frac{4\pi^2 r^{\cancel{2}}}{T^2 \cancel{r}}$$

eg. Emily swings a 500g mass in a 0.73m radius circle in 1.5s. What is the tension in the force sensor when she swings (remember v=d/t= $\underline{2\pi r/T}$ where T is period)

a) horizontally



$t = 1.5s = T$

$$F_t = F_{net} = \frac{mv^2}{r}$$

$$\frac{m\left(\frac{2\pi r}{T}\right)^2}{r}$$

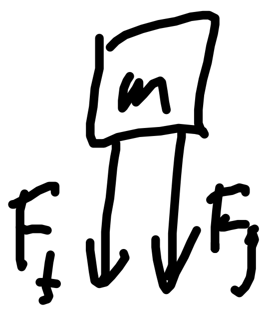
$$\frac{m\,4\pi^2 r}{T^2}$$

$$F_t = \frac{(0.50kg)(4\pi^2)(0.73m)}{\;}$$

$$F_t = \frac{\ldots}{(1.5s)^2}$$

$$F_t = 6.4043N = \boxed{6.4N}$$

b) vertically at the top



$$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

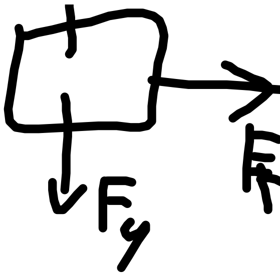
$$F_{net} = ma = F_t + F_g$$

$$F_t = F_c - F_g$$

$$F_t = 6.4043N - 4.9N$$

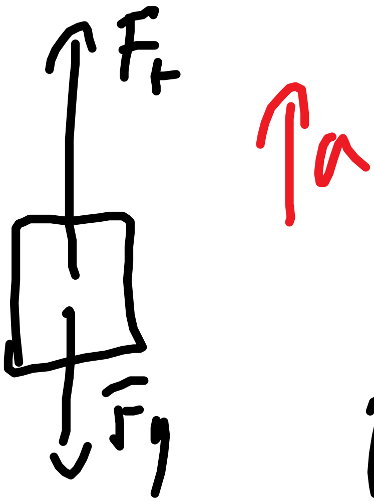
$$\boxed{F_t = 1.5N}$$

c) vertically at the side



$F_c = \boxed{6.4N}$

d) vertically at the bottom



$$F_{net} = F_t - F_g = F_c$$

$$F_t = F_c + F_g$$

$$F_t = 6.4N + 4.9N$$

$$= \boxed{11.3N}$$

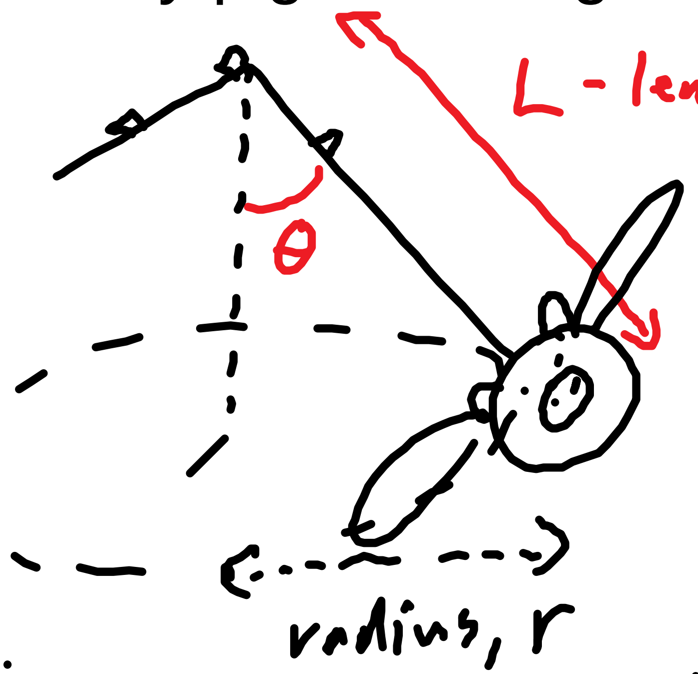
p119 Q1,3,5, and 120 Prob.1,3,5
finish the free body diagrams worksheet

Lab - Flying Pig (not in lab manual but it is related to p51 to 55)

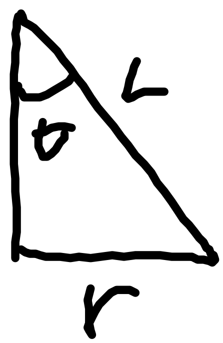
Purpose: Look at factors that influence the period of revolution of a toy on a string moving in circular motion.

Hypothesis:

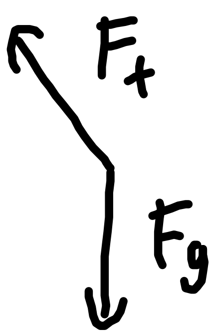
Toy pig with wings on a string:



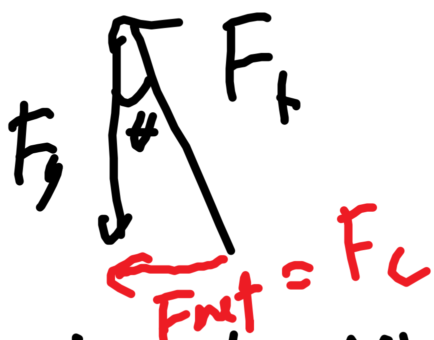
L - length - from rotation point to centre of mass



$\sin\theta = \frac{r}{L}$



free body diagram



Vector Addition

diagram

$$\tan\theta = \frac{F_c}{F_g}$$

for small θ

$$\sin\theta \sim \tan\theta$$

$$\frac{\cancel{r}}{L} = \frac{F_c}{F_g} = \frac{\cancel{m}\,4\pi^2\cancel{r}}{\cancel{m}\,g\,T^2}$$

$$\frac{r}{L} = \frac{m4\pi^2 r}{mgT^2}$$

$$mgT^2 r = m4\pi^2 r L$$

$$T^2 = \frac{\cancel{m}\,4\pi^2\cancel{r}\,L}{\cancel{m}\,g\,\cancel{r}}$$

$$\boxed{T^2 = \frac{4\pi^2}{g} L} \; *$$

graph T^2 vs L slope $= \frac{4\pi^2}{g}$ theory

Procedure - leave space

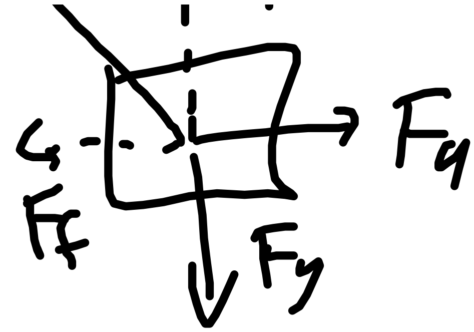
Observations - measure L from centre of the pig to each piece of tape on the string

Length, L (m)	time for 3 revolutions (s) t	Period squared T^2 (s^2)
0.51	6.0 $(\div 3)^2 =$	4.0
0.63		

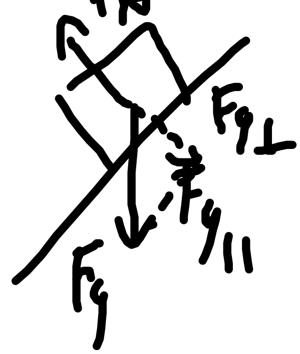
Graph T^2vsL %error slope vs $4\pi^2/g$

Quiz

(a)

1a) 

b) $F_f = \mu F_N$ $\quad \mu = \frac{F_f}{F_N} = \frac{\bigcirc}{3.5N}$ $\quad F_a$

c) 

d) $F_{net} = F_{g\parallel}$ (F_N cancels $F_{g\perp}$)

$= F_g \sin\theta$

$= 3.50N \sin \_\_$

e) $F_a = F_{g\parallel} + F_f$

$F_a = F_g \sin\theta + \mu F_g \cos\theta$

$= 3.56N(\sin\_ + 0.23\cos\_)$

f) $a = \frac{F_{net}}{m} = \frac{}{F_g/g}$ $\qquad \frac{V_f^{2} - V_i^{2}}{2a} = d$ $\qquad (0^2, (4\,m/s)^2)$

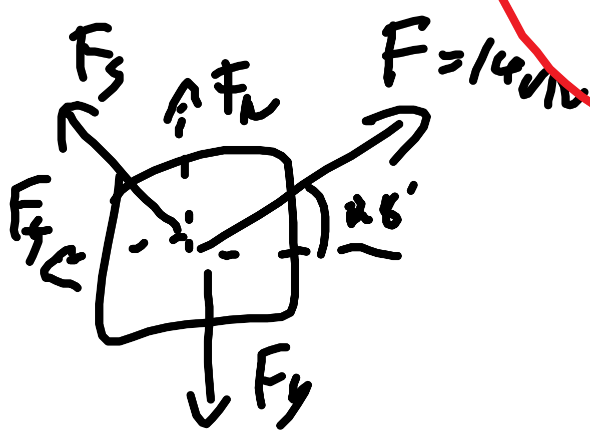
g) $t_{up} = \frac{V_f - V_i}{a} = \frac{0 - 4\,m/s}{}$

$a_{down} = \frac{F_{g\parallel} - F_f}{m}$

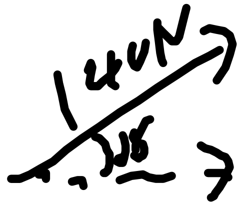
$d = \frac{1}{2}at^2$

$t_{down} = \sqrt{\frac{2d}{a_{down}}}$

Q2



a)

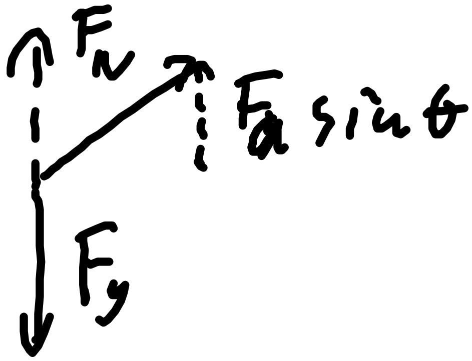


123.613

$F_H = F\cos\theta = 140\cos 28 = \boxed{120N}$

$F_H = F\cos\theta$ ...

b)



$$a_y = 0 \quad \therefore \quad F_N + F_a \sin\theta = F_g$$

$$F_N = F_g - F_a \sin\theta$$

$$= 45(9.8) - (140 \sin 28$$

$$= 375.27$$

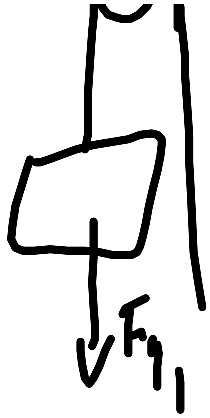
$$\boxed{3.8 \times 10^2 \, N}$$

c) $$a = \frac{F_{net}}{m} = \frac{F_a \cos\theta - \mu F_N}{m}$$

$$a = \frac{123.61N - 0.30(375.27)}{45}$$

$$= \boxed{0.25 \, m/s^2}$$

2a) $F_{net} = F_{..} + F_{..}$

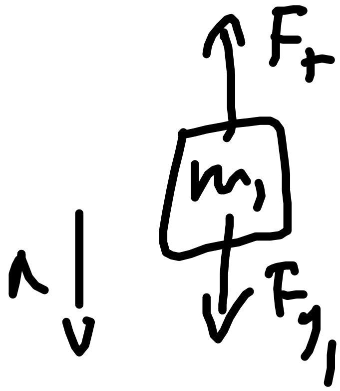


3a) $F_{net} = F_{g_1} + F_{g_{\parallel}}$

$$a = \frac{(m_1 + m_2 \sin\theta) g}{m_1 + m_2}$$

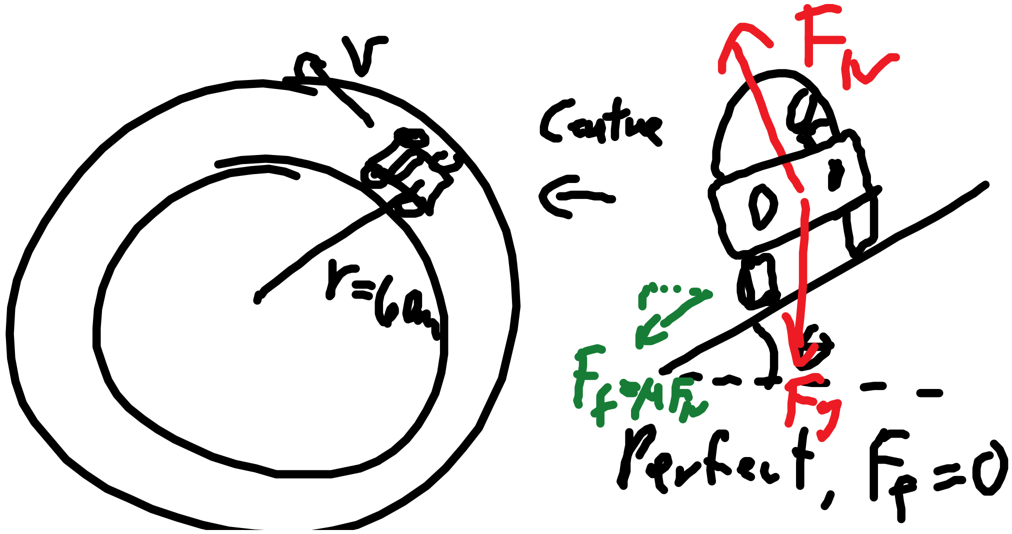
$$a = \frac{(0.20 + 0.40 \sin(\ )) 9.8}{0.2 + 0.4}$$

b) $$a = \frac{m_1 g + m_2 g \sin\theta - \mu m_2 g \cos\theta}{m_1 + m_2}$$

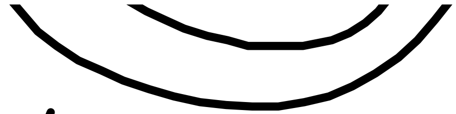


$m_1 a = F_{g_1} - F_T$

Q15

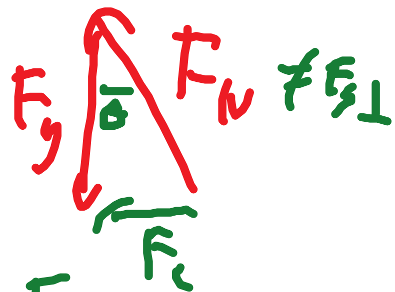


Perfect, $F_f = 0$



top view

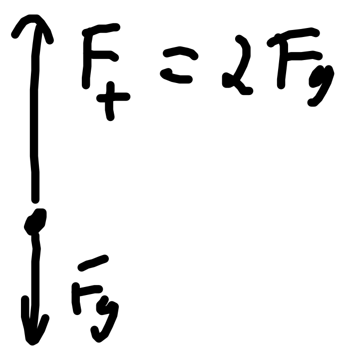
Perfect, $F_f = 0$



$$\tan\theta = \frac{F_c}{F_g}$$

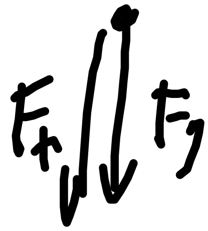
$$\theta = \tan^{-1} \frac{\cancel{m} v^2}{\cancel{m} g r} = \frac{(60/3.6)^2}{9.8(60)}$$

$$\theta = 25.287^\circ = \boxed{25^\circ}$$

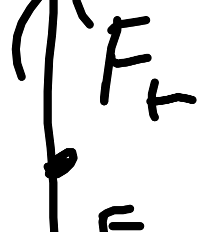


$a \uparrow = 9.8\ m/s^2$

Q47



Q20



Q14/15

F_g

F_g

$F_t = F_g + F_c$

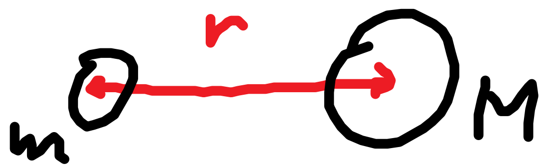
$F_t = F_g + \frac{mv^2}{r}$

http://hsfs2.ortn.edu/myschool/mperkins/PostMock/FBD%20practice%20-%20KEY.pdf

Tuesday, November 17, 2015
9:35 AM

Gravity
review-
Newtonian gravity -
$F_g = mg$
but g is different at equator, North Pole, Moon,

$F_g = GMm/r^2$



M and m are the masses of any two objects in the universe.
You don't feel this attraction to objects other than the Earth because

1. it is generally too small - masses are small compared to Earth or r is far.
2. you are in freefall - both you and the Earth are falling together to the sun.
   You can observe it through tides - different pull(component) at different points.r is the distance between the masses, m and M (use the centre of

mass).

F_g is the force of attraction pulling M and m together. It is always equal on each mass.

G is universal gravitational constant $6.67 \times 10^{-11} Nm^2/kg^2$

watch out - r is in metres convert from km to m.

(Einstein - gravity is warping space/time - cell phone timing)

eg. A 50.0 kg student and a 70.0 kg student are 1.5m apart and on Earth, Mass of 5.98×10^{24} kg and radius 6.38×10^6m.

a) what is the gravitational attraction between the students?
b) what is the minimum coefficient of friction that will keep them from sliding together
c) calculate g given the data in the

question on earth and at a height of 400 km

Gravity - Newton's Theory

We know that the weight of an object is dependent on its mass

$F_g = mg$

but g is dependent on other variables (9.8 N/kg near Earth but can change)

Newton's theory - all masses attract all other masses.

The amount of attraction is dependent on the amount of the two masses, m and M, and the distance between m and M, r.

$F_g = GMm/r^2$

F_g is the attraction on each mass. Note it is the same on each mass but opposite direction.

Why don't we feel the attraction to your neighbour, or the Sun?

1. the force is very small for most masses or for masses that are very far
2. You are in freefall with the Earth towards the Sun. You can observe the effects on the tides - caused by the components of F_g pulling along the surface.

G is the universal gravitational constant = $6.67 \times 10^{-11} Nm^2/kg^2$

- Note the units of distance are in m not km. always switch from km to m.

Einstein - masses warp space-time.

Thursday, November 19, 2015
8:44 AM

Quiz 1

a) $a_c = \frac{v^2}{r}$

$= \frac{15^2}{90} = 2.50\ m/s$

$2.5\ m/s^2$

$/2$

b) $F_f = \mu F_N = F_c$

$\mu \cancel{m} g = \cancel{m} a_c$

$\mu = \frac{a_c}{g} = \frac{2.5}{9.80} = \boxed{0.26}$

0.2551

$\boxed{0.255}$

$/2$

c)

$1.5/2$

$F_c = F_N \sin\theta$

$\tan\theta = \frac{F_c}{F_g} = \frac{a_c}{g}$

$F_c = F_N \sin\theta$ $\quad F_c \quad \tan\theta = \frac{F_c}{F_g} = \frac{\ \ }{g}$

$F_g = F_N \cos\theta$

$F_N = \frac{F_g}{\cos\theta}$

$\theta = \tan^{-1} 0.2551$

$\boxed{\theta = 14.3^\circ}$

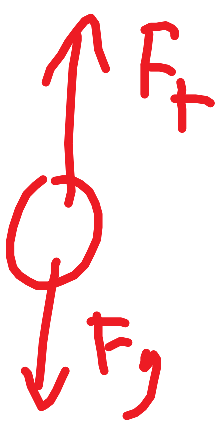
2.

$F_t = F_c = m\frac{4\pi^2 r}{T^2}$

$F_T = \frac{2.00kg \, 4\pi^2 (\cancel{0.65m}\ 1.2m)}{(0.65s)^2}$

$= \underline{224N}$ ✓ 2

b)



$F_c = F_t - F_g$

$F_t = F_c + F_g$

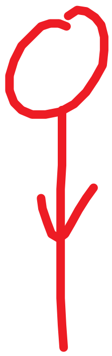
$= 224N + 2 \times 9.81$

$= \boxed{244N}$ ✓

✓2

$= \boxed{247\,N}$ ✓2

c)



$F_T = 0$

$F_c = F_g$

$$\frac{\cancel{m} v^2}{r} = \cancel{m} g$$

$$v = \sqrt{gr}$$

$$= \sqrt{9.8(1.2)}$$

$$= \boxed{3.43\,m/s}$$

✓2

Orbits

Planets orbit the Sun

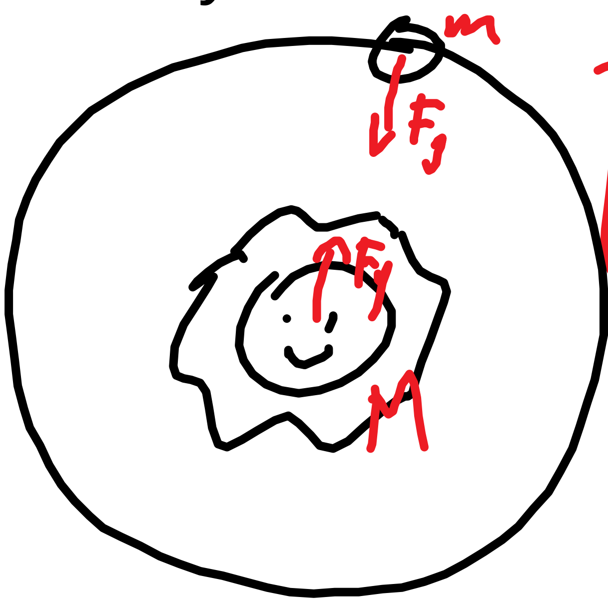
Moons and satellite

moons and satellites orbit planets

Keppler found that the average radius of the planetary orbits, r, is related to the period of revolution, T by the equation
r^3/T^2 = a constant

Newton looked at a proof of Keppler's Law

Planetary orbits are ellipses but let's pretend they are circles.



$$\boxed{F_c = F_g} \; *$$

$$m\frac{v^2}{r} = \frac{m4\pi^2 r}{T^2}$$

$$\frac{\cancel{m}4\pi^2 r}{T^2} = \frac{GM\cancel{m}}{r^2}$$

$$\frac{\cancel{m}\,4\pi^2 r}{T^2} = \frac{GM\cancel{m}}{r^2}$$

mass of the Earth cancels out

$$4\pi^2 r^3 = GMT^2$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

constant

If the international space station is 400km above the Earth's surface, determine

a) the orbital speed
b) the orbital period of the space station
c) what would be the height of a satellite that is in geostationary orbit. (over the same point)

eg. A 50.0 kg student and a 70.0 kg student are 1.5m apart and on Earth, Mass of 5.98 x 10^{24} kg and radius 6.38 x 10^{6}m.

a) what is the gravitational attraction between the students?

$$F_g = \frac{GMm}{r^2} = $$

$$\frac{6.67\times10^{-11}\frac{Nm^2}{kg^2}(70kg)(50kg)}{(1.5m)^2} = \boxed{1.0\times10^{-7}N}$$

b) what is the minimum coefficient of friction that will keep them from sliding together

$$\mu = \frac{F_f}{F_N} = \frac{F_g}{mg} = \frac{1.0\times10^{-7}N}{70(9.8)} = \boxed{1.5\times10^{-10}}$$

$= \boxed{1.5 \times 10^{-10}}$

c) calculate g given the data in the question on earth and at a height of 400 km

$$F_g = \cancel{m} g = \frac{GM\cancel{m}}{r^2}$$

$$g = \frac{6.67 \times 10^{-11} \frac{N m^2}{kg^2} (5.98 \times 10^{24} \cancel{kg})}{(6.38 \times 10^{6} m)^2}$$

$$= 9.799 = \boxed{9.80 \frac{N}{kg}}$$

Space station

$$\frac{6.67 \times 10^{-11} (5.98 \times 10^{24})}{(6.38 \times 10^{6} + 400\,000)^2}$$

$$\overline{(6.38\times10^6 + 400\,000)^2}$$

$$= \boxed{8.6\ N/kg}$$

If the international space station is 400km above the Earth's surface, determine

a) the orbital speed

$$g = a_c$$

$$8.6\frac{N}{kg} = \frac{v^2}{r} \qquad v = \sqrt{8.6 \times 6.78\times10^6}$$

$$= \boxed{7.4\times10^3\ m/s}$$

b) the orbital period of the space station

$$g = \frac{4\pi^2 r}{T^2}$$

$$T = \sqrt{\frac{4\pi^2 r}{g}} = 2\pi\sqrt{\frac{6.78\times10^6}{8.6}} = 5500s$$

$$= 92 min$$

a) what would be the height of a satellite that is in geostationary orbit. (over the same point)

Block 1-1

eg. A 50.0 kg student and a 70.0 kg student are 1.5m apart and on Earth, Mass of 5.98×10^{24} kg and radius 6.38×10^{6}m.

a) what is the gravitational attraction between the students?

$F_g = GMm/r^2$

$= 6.67\times10^{-11}\text{Nm}^2/\text{kg}^2(50\text{kg})(70\text{kg})/(1.5\text{m})^2$

$= \boxed{1.0 \times 10^{-7}\text{N}}$

b) what is the minimum coefficient of friction that will keep them from sliding together

$F_g = F_f = \mu F_N = \mu mg$ $\mu = F_g/mg$

$\mu = 1.0 \times 10^{-7}\text{N}/(50\text{kg}\times 9.8\text{N/kg})$

$= 2.0 \times 10^{-10}$

very small

c) calculate g given the data in the question on earth and at a height of 400 km

g=9.8N/kg right

$\cancel{m}g=F_g = GM\cancel{m}/r^2$

$g=GM/r^2$

$$g=6.67\times10^{-11}\,\text{N}\cancel{\text{m}^2}/\text{kg}^{\cancel{2}}(5.98\times10^{24}\,\cancel{\text{kg}})/(6.38\times10^{6}\,\cancel{\text{m}})^{\cancel{2}}$$

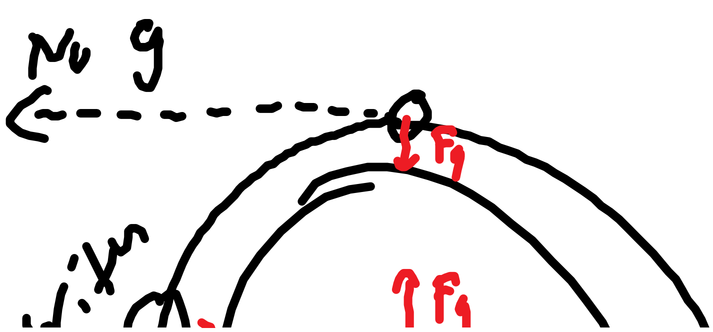
g= 9.799 = 9.8N/kg On Earth

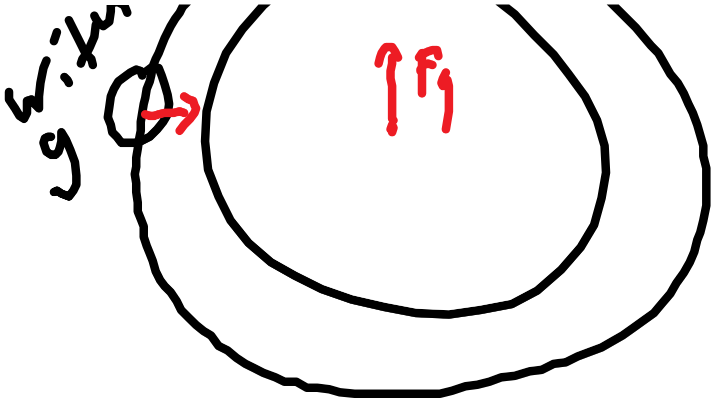
On the international space station

$$g=6.67\times10^{-11}\,\text{Nm}^2/\text{kg}^2(5.98\times10^{24}\,\text{kg})/(6.38\times10^{6}\,\text{m} + 400\ 000\,\text{m})^2$$

g=8.67696 = 8.7N/kg

Hey, why do the astronauts float when there is lots of gravity at that height? They are falling along with the station but move fast enough that the fall matches a circular trajectory.





Big Idea:
For orbital motion, the only force on the orbiting object is gravity.
therefore

$$\boxed{F_g = F_c}$$

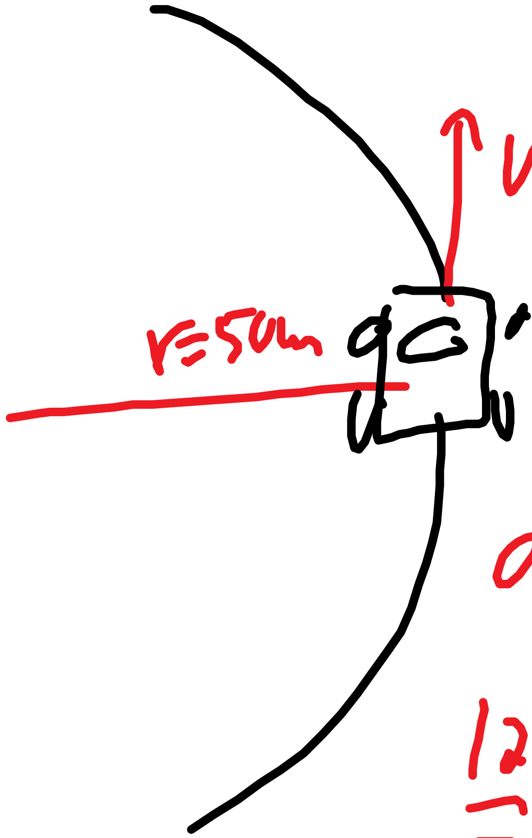
$$\boxed{GMm/r^2 = m\, v^2/r = m\, 4\pi^2 r/T^2}$$

eg. The international space station is at a height of 400km. Determine

a) the orbital speed
b) the orbital period
c) what is the height of a satellite in geostationary(stays over the same place on Earth) orbit?

Quiz

Q1



a) $a_c = \frac{v^2}{r}$

$\frac{12^2}{50}$ or $\frac{17^2}{50}$

$2.88\,m/s^2$ $5.78\,m/s^2$

b) $F_f = F_c$

$\mu \cancel{m} g = \cancel{m} a_c$

$\mu = \frac{a_c}{g}$

0.29 0.59

c)

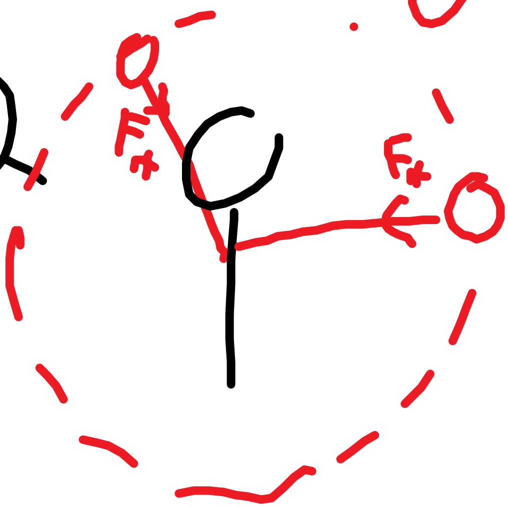
$\tan\theta = \frac{F_c}{F_g}$

1

$$\tan\theta = \frac{\cancel{m} a_c}{\cancel{m} g}$$

$$\theta = 16.3^\circ \text{ or } 30.5^\circ$$

2

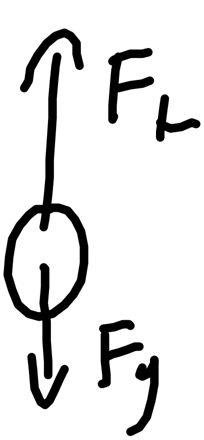


$$F_t = F_c = \frac{m 4\pi^2 r}{T^2}$$

$$= \frac{2\,\text{kg}\, 4\pi^2 (1.5\,\text{m})}{(0.65\,\text{s})^2}$$

$$= \underline{2.80\times10^2\,\text{N}}$$

or $\underline{74.4\,\text{N}}$

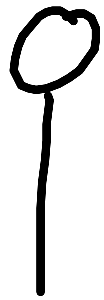


$$F_c = F_t - F_g$$

$$F_t = F_c + F_g$$

$\uparrow 2kg \times 9.8 \frac{N}{1kg}$

$= 94.4N$ or $300N$

c)  minimum speed $F_t = 0$

$F_c = F_g$

$\frac{\cancel{m}v^2}{r} = \cancel{m}g$

$v = \sqrt{gr}$

$2.89 m/s$ or $3.85 m/s$

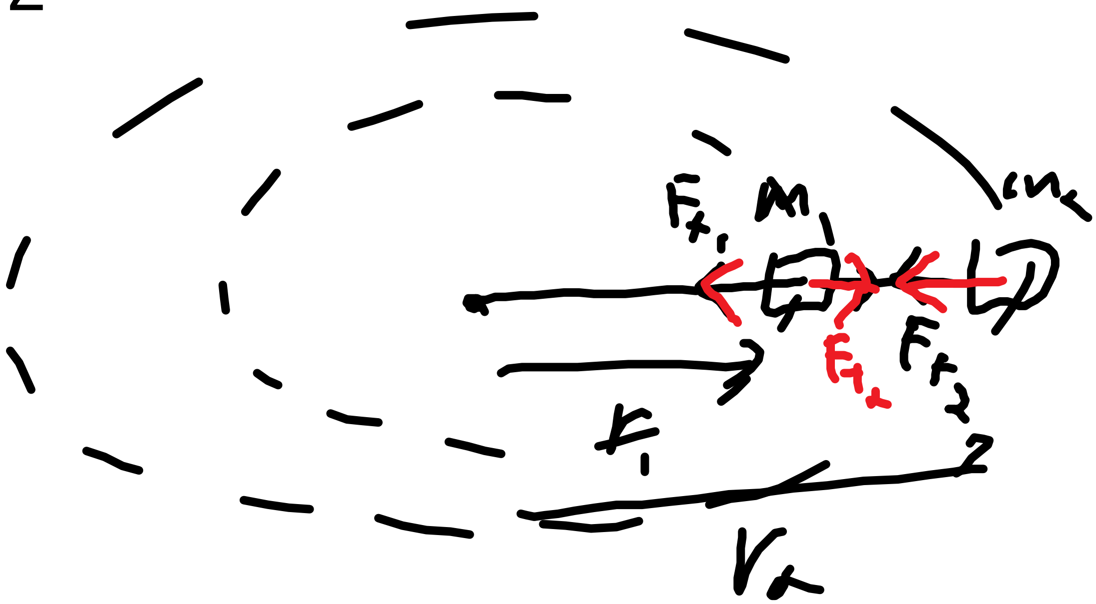
eg. The international space station is at a height of 400km. Determine

a) the orbital speed
b) the orbital period
c) what is the height of a satellite in geostationary(stays over the same place on Earth) orbit?

Block 1-2

Q 13

$$f = \frac{1}{T}$$



$$F_{T_2} = ma = m_2 \frac{4\pi^2 r_2}{\cancel{T^2}} f^2$$

$$a = \frac{4\pi^2 r}{T^2} \quad f = \frac{1}{T}$$

$$a = 4\pi^2 r f^2$$

$$F_{T_2} = m_2 4\pi^2 r_2 f^2$$

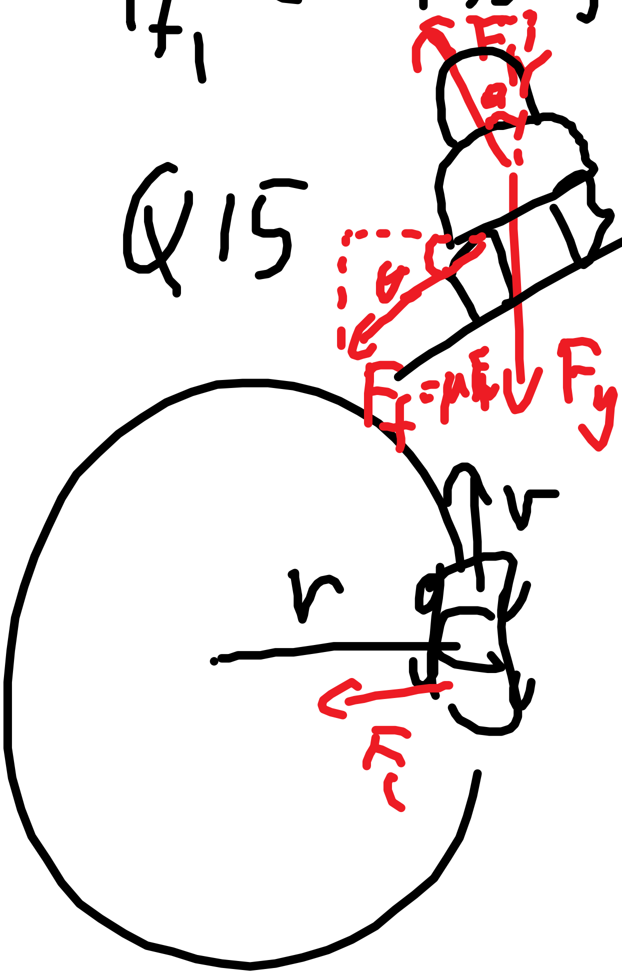
$$F_c = F_{T_1} - F_{T_2}$$

$\overleftarrow{a}$ $F_{t_1} = F_c + F_{t_2}$

$$F_{t_1} = m_1 4\pi^2 r_1 f^2 + m_2 4\pi^2 r_2 f^2$$

$$F_{t_1} = 4\pi^2 f^2 (m_1 r_1 + m_2 r_2)$$

Q15



$$\tan\theta = \frac{F_c}{F_g} = \frac{\cancel{m}v^2}{\cancel{m}gr}$$

$$\tan\theta = \frac{v^2}{gr}$$

$$\tan\theta = \frac{(60/3.6\ \frac{m}{s})^2}{9.8\frac{m}{s^2}(6\ 0m)} =$$

$$\theta = 25.287 = \boxed{25^\circ}$$

x $\quad F_{\cancel{g}} = F_c$

y $\quad F_{net} = 0$

$$x = F_c = F_N \sin\theta + \mu F_N \cos\theta$$

$$y = 0 = F_y + \mu F_N \sin\theta = F_N \cos\theta$$

eg. A 50.0 kg student and a 70.0 kg student are 1.5m apart and on Earth, Mass of 5.98 x 10^{24} kg and radius 6.38 x 10^6m.

a) what is the gravitational attraction

between the students?

$F_g=GMm/r^2$

$=6.67x10^{-11}Nm^2/kg^2(50kg)(70kg)/(1.5m)^2$

$=1.04x10^{-7}N$

b) what is the minimum coefficient of friction that will keep them from sliding together

$F_f=F_g$ between the students

$\mu F_N=1.04x10^{-7}N$

$\mu=1.04x10^{-7}N/(50kgx9.8N/kg)$

$\mu= 2.0x10^{-10}$

c) calculate g given the data in the question on earth and at a height of 400 km

g=9.80N/kg right?

let's check

$F_g=\cancel{m}g=GM\cancel{m}/r^2$

$g=GM/r^2$

$g=6.67x10^{-11}N\cancel{m^2}/kg^{\cancel{2}}x5.98x10^{24}\cancel{kg}$

$/(6.38x10^6\cancel{m})^2$

$= 9.799 = 9.80m/s^2$

On the international space station:

h=400km, so

$g = 6.67\times10^{-11}\,Nm^2/kg^2 \times 5.98\times10^{24}\,kg$

$\quad /(6.38\times10^{6}\,m + 400\,000\,m)^2$

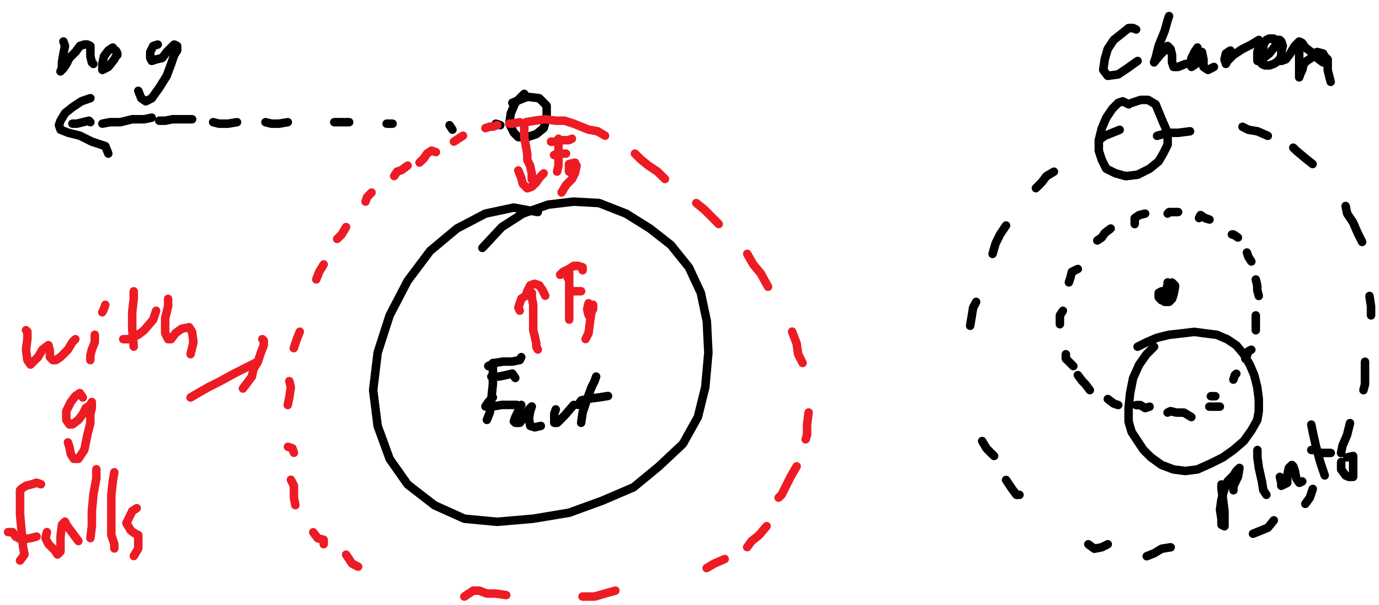
$= 8.7$ N/kg

Hey why are they apparently weightless?

Because they are in freefall.

If you are in an elevator that is falling, you would feel "weightless" even if you are near Earth.

The space station is falling but moving fast enough that it falls in a circular orbit.



$$\boxed{F_c = F_g}$$

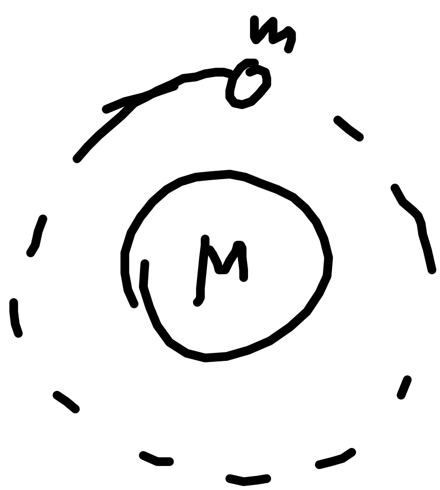
orbital motion

$$\boxed{\frac{mv^2}{r} = \frac{m4\pi^2 r}{T^2} = \frac{GMm}{r^2}}$$

1. Determine the orbital period and speed of the international space station.
   h=400km M_{earth}=5.98x10^{24}kg
   r_{Earth}=6.38 x 10^6m
2. What is the height of a geostationary orbit? (over the same point of the Earth the whole time)

Monday, November 23, 2015
8:43 AM

1. Determine the orbital period and speed of the international space station.
   $h = 400 km$ $M_{earth} = 5.98 \times 10^{24} kg$
   $r_{Earth} = 6.38 \times 10^6 m$
2. What is the height of a geostationary orbit? (over the same point of the Earth the whole time)



$$F_c = F_g$$

$$\frac{\cancel{m} v^2}{\cancel{r}} = \frac{G M \cancel{m}}{r^{\cancel{2}}}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$v = \sqrt{\frac{6.67 \times 10^{-11} \; 5.98 \times 10^{24}}{(6.38 \times 10^6 + 400\,000 m)}}$$

$$\boxed{v = 7.67 \times 10^{3}\ m/s}$$

$$\frac{4\pi^2 r}{T^2} = \frac{GM}{r^2}$$

$$T^2 = \frac{4\pi^2 r^{3}}{GM}$$

$$T = 2\pi\sqrt{\frac{(6.78\times10^{6})^{3}}{6.67\times10^{-11}(5.98\times10^{24})}}$$

$$T = 93\text{ minutes} = 5550\ s = 1.5\ hrs$$

2 geostationary - period = 1 day must be over the equator

T= 1x24x3600=<u>86400 s</u>
r=?

$$\underline{F_c} = \underline{F_g} \qquad a_c = g$$

$$\frac{4\pi^2 r}{T^2} = \frac{GM}{r^2}$$

$$\frac{\cancel{m} 4\pi^2 r}{T^2} = \frac{GM\cancel{m}}{r^2}$$

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$r = \sqrt[3]{\frac{6.67\times10^{-11}(5.98\times10^{24})(86400\,s)^2}{4\pi^2}}$$

$$\underline{r = 4.23\times10^7\ m}$$

$$h = r - r_E = \boxed{3.59 \times 10^{7}\,m}$$

signals are delayed by $3.6\times10^{7}/3.0\times10^{8}$ (speed of light)

x 2 = over 0.2s

p96

Q54, 55, 59, 61, 63

p123 Q 51,52, 54, 56, 62

p96 Problem 55

$$F_{net} = ma = mg\mu$$

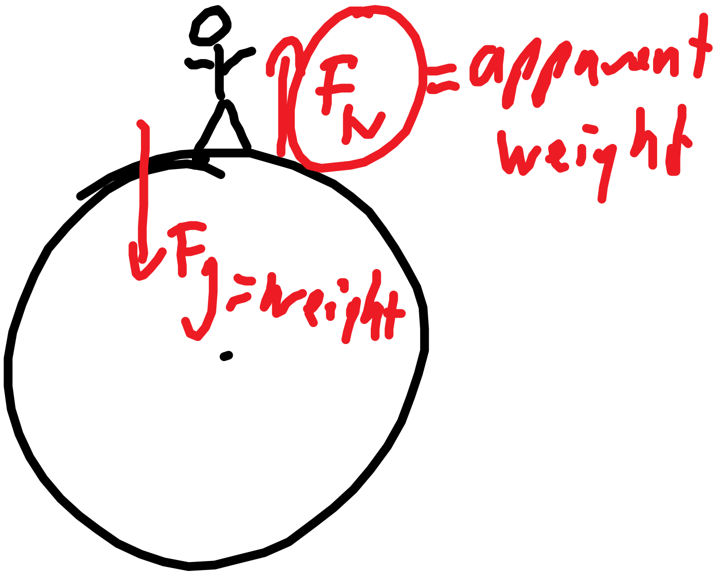
$$0.20g = g\mu$$

$\mu = 0.20$

p123 problem 54

$$\frac{4\pi^2 r}{T^2} = a_c$$

H



$$a_c = \frac{4\pi^2 r}{T^2} = \frac{4\pi^2 (6.38\times10^6)}{(86400\,s)^2}$$

1 day

$$a_c = 0.03374\ m/s^2$$

$$\text{fraction} = \frac{a_c}{g} = \frac{0.03374}{9.80} = \boxed{0.00344}$$

... of 9.80 = $\boxed{9.77\ m/s ...}$

istend of 9.80 = $\boxed{9.77\,m/s^2}$

p 123 Q52

$\bar{F}c = \bar{F}net = \bar{F}_T - \bar{F}g = 1200N - 85kg \times 9.8N/kg$
$= 367N$

$\bar{F}c = \frac{mv^2}{r}$

$v = \sqrt{\frac{Fc \times r}{m}} = \sqrt{\frac{367N \times 4.8m}{85kg}} = 4.6m/s$

p96 Q54

$a = 30g = -9.80m/s^2 \times 30$
$= -294m/s^2$

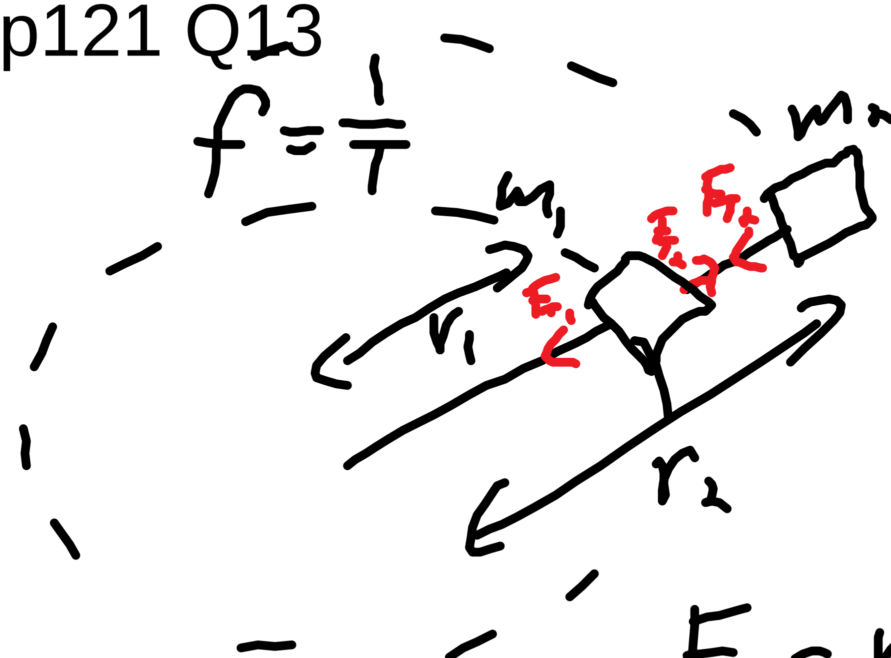
$F = ma = 70 \times 294 = \boxed{20580N}$

$90km/h = 25m/s$

$V_f^2 = V_i^2 + 2ad \quad 25^2/2 \div 294m/s^2 = 1.06m$

Block 1-1
p121 Q13

$$f = \frac{1}{T}$$



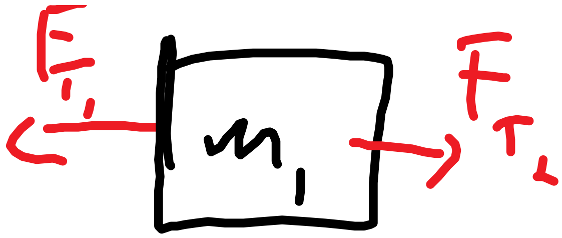
$$F_{T_2} = F_c$$

$$F_c = m\frac{v^2}{r} = m\frac{4\pi^2 r}{T^2}$$

$$F_c = m 4\pi^2 r f^2$$

$$f = \frac{1}{T}$$

$$\boxed{F_{T_2} = m_2 4\pi^2 r_2 f^2}$$



$$F_c = F_{T_1} - F_{T_2}$$

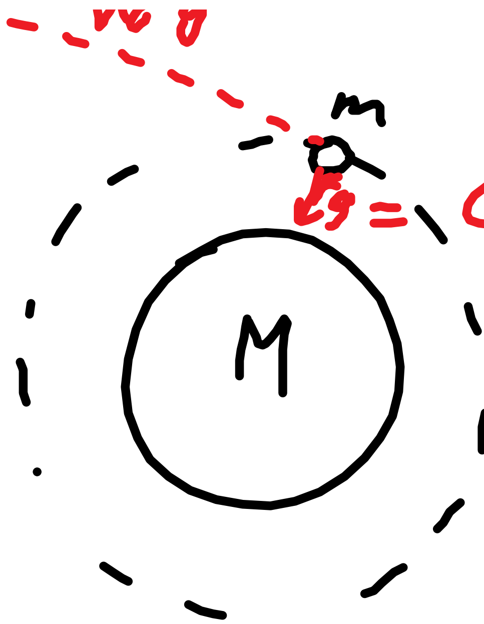
$$F_{T_1} = F_{T_2} + F_c$$

$$F_{T_1} = m_2 4\pi^2 r_2 f^2 + m_1 4\pi^2 r_1 f^2$$

$$= 4\pi^2 f^2 (m_2 r_2 + m_1 r_1)$$

1. Determine the orbital period and speed of the international space station.
   $h = 400\text{km}$ $M_{earth} = 5.98 \times 10^{24}\text{kg}$
   $r_{Earth} = 6.38 \times 10^6\text{m}$
2. What is the height of a geostationary orbit? (over the same point of the Earth the whole time)

$F = F$



$$F_g = F_c$$

$$F_g = \frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$v = \sqrt{\frac{6.67\times10^{-11}\,(5.98\times10^{24})}{(\underbrace{6.38\times10^{6}}_{r_E} + \underbrace{400{,}000\text{ m}}_{h})}}$$

$$\boxed{v = 7.67\times10^{3}\text{ m/s}}$$

b) $$\frac{GM\cancel{m}}{r^2} = \frac{\cancel{m}4\pi^2 r}{T^2}$$

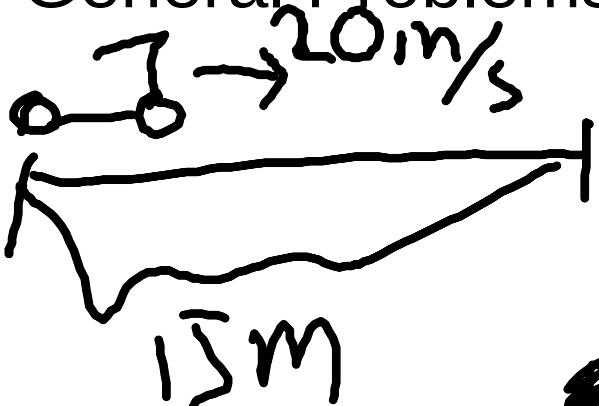
$$T^2 = \frac{4\pi^2 r^3}{\ldots}$$

GM

$T = 5554\ s = 93\ minutes = 1.5\ hrs$

p96
General Problems 54, 55, 59, 61, 63
p123 General Problems 51,52, 54, 56, 62

p96
Q61



$F_a = 0$

$F_{net} = F_a - F_{fr}$

$a = -0.80 \times 9.8$

$= 7.84\ m/s^2$

$0^2 = 20^2 - 2 \times 7.84 \times d$

$d = 25.5m$

$V_f^2 = 20^2 - 2(7.84) \times 15$

$V_f^2 = 164.8$

$V_f = 12.84\ m/s$

P 123

Q 54) $w = m\left(g - \left(\frac{2\pi}{T}\right)^2 r\right)$

$\cancel{m}g = \cancel{m}\left(g - \left(\frac{2\pi}{T}\right)^2 r\right)$

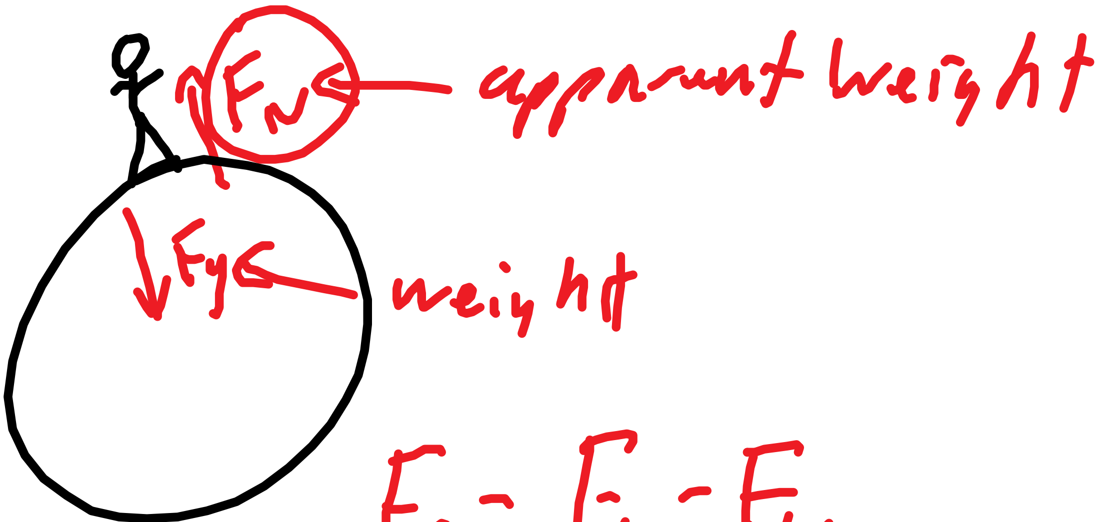
$g - g$

$\Delta g = -\left(\frac{2\pi}{T}\right)^2 r$

$\Delta g = -\frac{4\pi^2}{T^2} r$

$= -\frac{4\pi^2 (6.38 \times 10^6)}{(8.64 \times 10^4)^2}$

$\Delta g = -0.0337\ m/s^2$



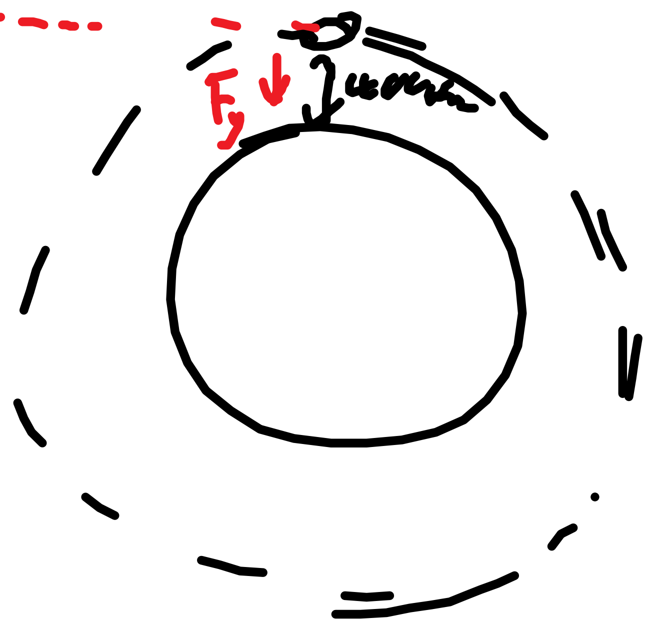
$$F_c = F_g - F_N$$

$$F_N = F_g - F_c$$

1. Block 1-2
   1. Determine the orbital period and speed of the international space station.
      $h=400km$ $M_{earth}=5.98x10^{24}kg$
      $r_{Earth}=6.38 \times 10^6 m$
2. What is the height of a geostationary orbit? (over the same point of the Earth the whole time)

P96 GP 54,55,59,61,63
p123 GP 51,52,54,56,62

p123 GP 31,32,34,36,62



$$\boxed{F_c = F_g}$$

$$m\frac{v^2}{r} = \frac{GM\cancel{m}}{r^2}$$

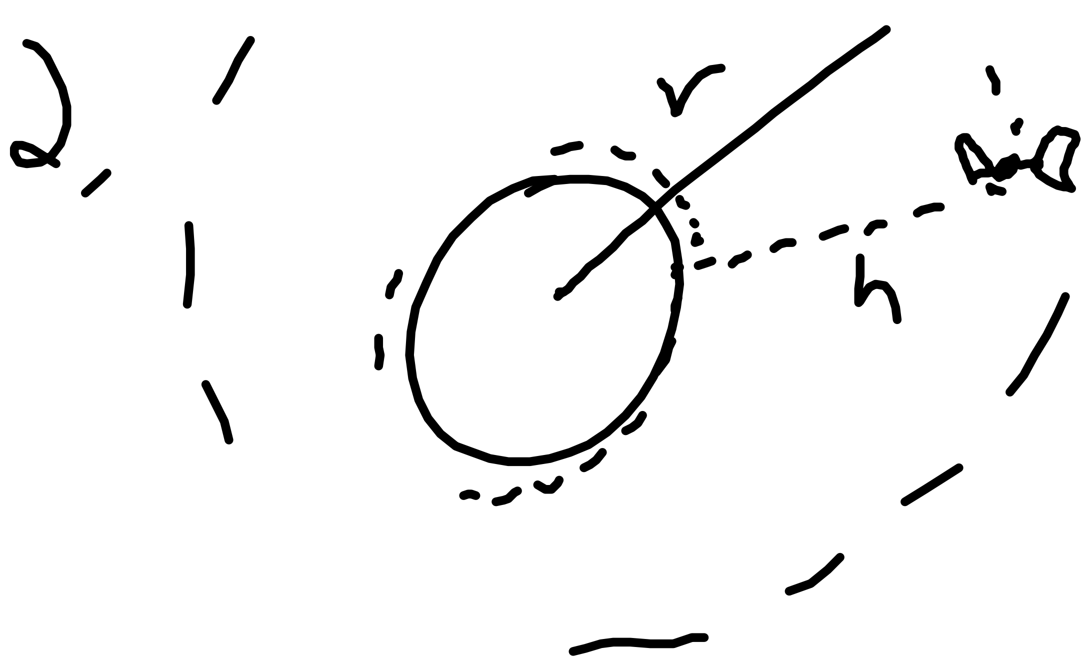
$$v = \sqrt{\frac{GM}{r}} = \boxed{7.67\times10^3\ \text{m/s}}$$

$$\frac{\cancel{m}4\pi^2 r}{T^2} = \frac{GM\cancel{m}}{r^2} \qquad T^2 = \frac{4\pi^2 r^3}{GM}$$

$$T = 5.556\,\text{s} = \boxed{1.5\ \text{hrs}}$$

$T = 5554\,s = \boxed{1.5\,hrs}$

2



Q54 $F_{net} = ma = 70\,kg \times 30 \times 9.8\,m/s^2$
$= 2.1 \times 10^4\,N$

$a = 30 \times -9.8$

$v_f^2 = v_i^2 + 2ad$

$0^2 = (25\,m/s)^2 + 2 \times 30 \times (-9.8\,m/s^2)\,d$

$d = 1.1\,m$

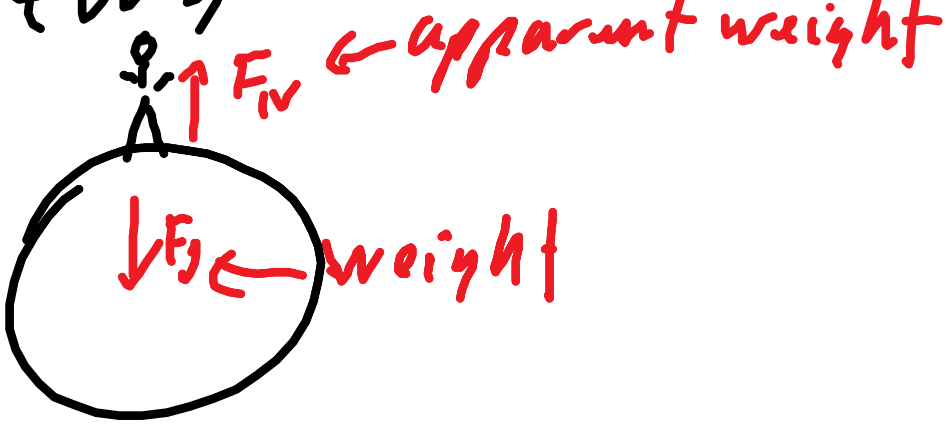
P12第 Q54 $\omega = 2\pi f$

$a = r\omega^2$

ω?

$$a_c = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

$$\frac{4\pi^2(6.38\times10^6\,m)}{(86400\,s)^2} = \underline{0.0337}\,m/s^2$$



$$9.80\ N/kg - 0.0377 = \boxed{9.77\ m/s^2}$$

$$\frac{0.0377}{9.8} = \underline{0.0034gs}$$

$$F_{g_r} = \frac{1}{2} F_{g_s}$$

$$\frac{\cancel{GMm}}{r_2^2} = \frac{1}{2}\frac{\cancel{GMm}}{r_E^2}$$

$$r_2^2 \sim r_E^2$$

$$2 r_E^2 = r_2^2$$

$$r_2 = \sqrt{2 r_E^2} = \sqrt{2}\, r_E$$